BMJ Open

Availability of Equipment and Medications for Non-Communicable Diseases and Injuries at Public First-Referral Level Hospitals: A Cross-sectional Analysis of Service Provision Assessments in Eight Low-Income Countries

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-038842
Article Type:	Original research
Date Submitted by the Author:	26-Mar-2020

Complete List of Authors:	Gupta, Neil; Harvard Medical School Department of Global Health and Social Medicine, Program in Global Noncommunicable Diseases and Social Change; Brigham and Women's Hospital, Division of Global Health Equity Coates, Matthew; Harvard Medical School Department of Global Health and Social Medicine, Program in Global Noncommunicable Diseases and Social Change; Brigham and Women's Hospital, Division of Global Health Equity Bekele, Abebe; Ethiopian Public Health Institute, Health System and Reproductive Health Research Directorate Dupuy, Roodney; Le Ministère de la Santé Publique et de la Population Fénelon, Darius Leopold; Zanmi Lasante Gage, Anna; Harvard T.H. Chan School of Public Health, Department of Global Health and Population Zemedu, Theodros ; Ethiopian Public Health Institute, Health System and Reproductive Health Research Directorate; University of Gondar College of Medicine and Health Sciences, College of Medicine and Health Science, Institute of Public Health Karmacharya, Biraj; Kathmandu University School of Medical Sciences, Department of Community Medicine Kwan, G.; Harvard Medical School Department of Global Health and Social Medicine, Program in Noncommunicable Diseases and Social Change; Boston University School of Medicine, Section of Cardiovascular Medicine Lulebo, Aimée ; University of Kinshasa, Kinshasa School of Public Health Masiye, Jones; Malawi Ministry of Health Mayige, Mary; National Institute for Medical Research Ndour Mbaye, Maïmouna; Cheikh Anta Diop University, Department of Internal Medicine, University Hospital Center of Dakar Mridha, Malay; BRAC University, Center for Non-communicable Diseases and Nutrition, BRAC James P Grant School of Public Health Park, Paul; Harvard Medical School Department of Global Health and Social Medicine, Program in Noncommunicable Diseases and Social Change; Brigham and Women's Hospital, Division of Global Health Equity Dagnaw, Wubaye; Partners In Health; Ethiopia Ministry of Health Wroe, Emily; Harvard Medical School Department of Global Health and Social Medicine, Program in Global Noncommunicable Diseases and Social Change; Brigham and Women's Hospital, Division of Global Health

	Equity Bukhman, Gene; Harvard Medical School Department of Global Health and Social Medicine, Program in Global Noncommunicable Diseases and Social Change; Brigham and Women's Hospital, Division of Global Health Equity
Keywords:	CARDIOLOGY, DIABETES & ENDOCRINOLOGY, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, TROPICAL MEDICINE, Asthma < THORACIC MEDICINE, SURGERY

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Availability of Equipment and Medications for Non-Communicable Diseases and Injuries at Public First-Referral Level Hospitals: A Cross-sectional Analysis of Service Provision Assessments in Eight Low-Income Countries

Authors: Neil Gupta[1,2,3], Matthew M Coates[1], Abebe Bekele[4], Roodney Dupuy[5], Darius Leopold Fénelon[6], Anna D Gage[7], Theodros Getachew[4,8], Biraj M Karmacharya[9], Gene F Kwan[1,3,10], Aimée Lulebo[11], Jones K Masiye[12], Mary Mayige[13], Maïmouna Ndour Mbaye[14], Malay K Mridha[15], Paul H Park[1,2,3], Wubaye Walelgne Dagnaw[3,16], Emily B Wroe[1,2,3], Gene Bukhman[1,2,3, 17]

Affiliations:

1. Department of Global Health and Social Medicine, Program in Global Noncommunicable Diseases and Social Change, Harvard Medical School, Boston, USA;
2. Division of Global Health Equity, Brigham & Women's Hospital, Boston, USA;
3. Partners In Health, Boston, USA
4. Health System and Reproductive Health Research Directorate, Ethiopian Public Health Institute, Addis Ababa, Ethiopia;
5. Le Ministère de la Santé Publique et de la Population, Port-au-Prince, Haiti
6. Zanmi Lasante, Haiti
7. Department of Global Health and Population, Harvard T. H. Chan School of Public Health, Boston, USA
8. College of Medicine and Health Science, Institute of Public Health, University of Gondar, Gondar, Ethiopia
9. Department of Community Medicine, Kathmandu University School of Medical Sciences, Dhulikhel, Nepal
10. Section of Cardiovascular Medicine, Boston University School of Medicine, Boston, USA
11. School of Public Health, Kinshasa, The Democratic Republic of the Congo
12. Malawi Ministry of Health, Lilongwe, Malawi
13. National Institute for Medical Research, Dar Es Salaam, Tanzania
14. Department of Internal Medicine, University Hospital Center of Dakar, Cheikh Anta Diop University, Dakar, Senegal
15. Center for Non-communicable Diseases and Nutrition, BRAC James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh
16. Ministry of Health, Federal Democratic Republic of Ethiopia, Addis Ababa, Ethiopia
17. Division of Cardiovascular Medicine, Brigham & Women's Hospital, Boston, USA

Corresponding author: Gene Bukhman, gene_bukhman@hms.harvard.edu, 641 Huntington Avenue Boston, Massachusetts 02115, +1-617-432-6052
Word count: 4203

Abstract

Context and Objectives

Non-communicable diseases and injuries (NCDIs) comprise a large share of mortality and morbidity in low-income countries (LICs), many of which occur earlier in life and with greater severity than in higher income settings. Our objective was to assess availability of essential equipment and medications required for a broad range of acute and chronic NCDI conditions.

Design

Secondary analysis of existing cross-sectional survey data

Setting

We utilized data from Service Provision Assessment surveys in Bangladesh, the Democratic Republic of the Congo, Ethiopia, Haiti, Malawi, Nepal, Senegal, and Tanzania, focusing on public first-referral level hospitals in each country.

Outcome measures

We defined sets of equipment and medications required for diagnosis and management of four acute and nine chronic NCDI conditions and determined availability of these items at the health facilities.

Results

Overall, 797 hospitals were included. Medication and equipment availability was highest for acute epilepsy (country estimates ranging from 40 to 95%) and stage 1-2 hypertension (28-83%). Availability was low for type 1 diabetes (1-70%), type 2 diabetes (3-57%), asthma (0-7%), and acute presentations of diabetes (0-26%) and asthma (0-4%). Few hospitals had equipment or medications for heart failure (0-32%), rheumatic heart disease (0-23%), hypertensive emergencies (0-64%), or acute minor surgical conditions (0-5%). Data for chronic pain was limited to only two countries. Availability of essential medications and equipment was lower than previous facility-reported service availability.

Conclusions

Our findings demonstrate low availability of essential equipment and medications for diverse NCDIs at first-referral level hospitals in eight LICs. There is a need for decentralization and integration of NCDI services in existing care platforms and improved assessment and monitoring to fully achieve universal health coverage.

Strengths and limitations of this study

- To our knowledge, this is the first analysis with cross-country comparisons of readiness at first-referral level hospitals for acute and chronic presentations of a broader range of non-communicable diseases and injuries in low-income countries using practical and well-defined clinical criteria.
- Valid cross-country analysis was possible by comparing facilities at analogous levels of the health system and using Service Provision Assessment data, which is largely standardized across countries.
- The Service Provision Assessment surveys lack longitudinal data, and our analysis does not include information about supply chains, limiting the nature of the description about the availability of medications and equipment.
- While we analyzed data from eight countries representing a variety of low-income countries geographically, there are many more countries excluded from our analysis.

Introduction

Non-communicable diseases (NCDs) and injuries (NCDIs) are major drivers of the disease burden in low-income countries (LICs), accounting for 41% of mortality and morbidity in terms of disability-adjusted life years (DALYs) in 2017.[1] In many LICs, the risk factors, epidemiology, and disease conditions that comprise the burden of NCDIs differs from that seen in higher income countries.[2] In these countries, harmful environments, infectious diseases, and poor access to timely and high-quality health services are important factors contributing to the burden of NCDs.[3,4]

Health-sector interventions to address this burden have been increasingly recognized as both cost-effective and equitable, particularly for severe NCDIs affecting individuals early in life.[2,5] In many LICs, availability of services to diagnose and manage NCDs is low and most often found primarily in urban higher-level hospitals.[4] However, several NCDI interventions may be optimally delivered at first-referral level hospitals, which have been recognized as an essential component of the primary health care system.[5] These first-referral hospitals, called district hospitals in some health systems, provide an opportunity to decentralize care, as they are more accessible to patients than tertiary referral hospitals and more capable of providing advanced services than health centers.[6,7] Populations in rural areas, which tend to have higher rates of poverty in LICs,[8] often face challenges accessing health care at distant facilities.[9] Although one study has shown low readiness of health facilities in five LICs to deliver general services for cardiovascular disease, diabetes, and chronic respiratory diseases,[4] there has been limited multi-country assessment of hospital capacity to deliver a broader range of priority NCDI interventions. Some facility surveys assessing readiness and quality of care for other types of care, such as for maternal health, have found lower quality in facilities located in areas with higher rates of poverty.[10]

In this study, we evaluated the availability of equipment and medications for management and diagnosis of the acute and chronic presentations of a broad range of NCDIs at first-referral level hospitals in eight LICs: Bangladesh, the Democratic Republic of the Congo (DRC), Ethiopia, Haiti, Malawi, Nepal, Senegal, and Tanzania. We selected specific NCDIs with potentially severe presentations early in life, including asthma, hypertensive emergencies, heart failure, rheumatic heart disease, type 1 and 2 diabetes, epilepsy, acute

surgical care, and chronic pain. Given previous findings linking poverty and healthcare quality, we examined whether there were associations between subnational prevalence of extreme poverty and availability of equipment and medications. To the best of our knowledge, the countries we included in this study are the only LICs with comparable, openly available, nationally representative data on NCDI service provision recently collected via a standardized survey.

Methods

Study Setting and Data Sources

We utilized publicly available data from all Service Provision Assessment (SPA) surveys conducted in LICs through 2018. The SPA surveys are nationally-representative health facility assessments administered as part of the Demographic and Health Survey (DHS) program.[11] These surveys were designed to assess human resources, infrastructure, equipment and medications available for maternal and child health (MCH) and priority infectious diseases.[11] In 2012, the SPA questionnaires were updated to include indicators for some NCDIs, including infrastructure, human resources, medications, equipment, and guidelines. Survey collectors indicate medications and equipment as available if they directly observe these items on the day of the survey.

Since the initial inclusion of questions on NCDs, SPA surveys had been completed as of 2018 in eight LICs representing a broad range of geography, population size, economic productivity, health care expenditure, and health system capacity: Bangladesh (2014), the DRC (2017-18), Ethiopia (2014), Haiti (2013), Malawi (2013-14), Nepal (2015), Senegal (2016-17), and Tanzania (2014-15) (Appendix Table 1).[12] Bangladesh subsequently graduated to low-middle income status in 2015. The surveys in Haiti and Malawi were facility censuses, intended to capture all health facilities in the country. In Nepal, all public facilities were in the sampling frame and almost all public hospitals were surveyed. All hospitals in Ethiopia were included in the survey collection, along with a representative sample of private clinics and health centers. In Tanzania, all types of facilities were in the sampling frame, and 99% of hospitals were selected for the sample. In the DRC, the survey was done using a stratified random sample to obtain results by province and type of health facility. In Bangladesh, the surveys were conducted on a stratified random sample of facilities to obtain representative estimates by seven administrative divisions and by facility types (including a census of public district hospitals but a sample of public upazila health complexes). The combined 2016 and 2017 surveys in Senegal

essentially includes a census of hospitals. Full details on the data from each country can be found in online reports, along with survey instruments.[12] Data from these surveys were obtained from the DHS program (www.dhsprogram.com).

We build on methods previously developed to assess the quality of primary health care using similar datasets.[13,14] The datasets were cleaned and standardized across the countries, categorizing facilities as hospitals, health centers and clinics, or other facilities such as dispensaries. Facility weights used in analysis accounted for survey design and nonresponse to ensure representativeness, as oversampling is often done for certain facility types in these surveys. Our assessment focused on public first-referral hospitals. We regarded first-referral level hospitals as the first point of care for patients requiring referral from a primary health center level, and the names for these facility types varied across countries. In Nepal, we classified public district hospitals as first-referral level hospitals. In Bangladesh, we classified upazila health complexes as first-referral level hospitals because they are described as hospitals with in-patient beds and surgical care, occupy a lower level than district hospitals in Bangladesh, and have population catchment areas similar to district hospitals in other countries (1 facility per 375,000 population, compared to a range across other countries of 1 facility per ~175,000-560,000). In Malawi and Tanzania, we combined public district hospitals with public rural/community hospitals (Malawi) and district designated hospitals (Tanzania) as first-referral level hospitals. In Haiti, we used the community referral hospital classification. In Senegal, we reported on all public hospitals because more specific categories were not available from the SPA data. In the DRC, we used public hospitals below the provincial/tertiary level, though we could not differentiate between additional categories from the available data. In Ethiopia, we used both primary hospitals and general hospitals given the relatively recent introduction of primary hospitals and similarities in service delivery standards. Additional details can be found in Appendix Table 1. The study protocol was reviewed and determined non-human subject research by the Institutional Review Board of the Harvard Faculty of Medicine.

Data Analysis

We analyzed the availability of essential equipment and medications required for diagnosis and treatment of nine chronic disease states and four acute presentations of eleven NCDI conditions (Table 1). We defined the minimum set of essential equipment and medications for the diagnosis and treatment of each condition

using existing guidelines and iterative expert review from a group of public health practitioners, researchers, and clinicians familiar with the local contexts. Acute conditions are those that require urgent procedures or hospitalization, whereas chronic conditions were those requiring longitudinal follow-up for ongoing monitoring and disease management. The availability of the full essential set of functioning equipment and unexpired medications was determined for each facility. We considered equipment available if it was present in general outpatient, NCD, or minor surgical areas. Medications were considered available if they were observed present and unexpired. In most cases, the data necessary to create these sets were available. In cases in which a survey question about one of the components of the equipment and medication set for a condition was not answered but the rest of the components were present at the facility, the facility received an "unknown" classification for that set. If any one of the components was unavailable, then the essential set was classified as unavailable. Surveys in some countries did not contain questions about all of the relevant medications and equipment. In these cases, as well as in countries with >10% missing data for a particular variable, the country was excluded from analysis (see Appendix Table 2 for list of missing variables). Missing variables and "unknown" classifications for a set of equipment and medications were rare, resulting most frequently from surveys in particular countries excluding certain pain medications or surgical equipment. A total of 21 out of 797 public first-referral hospitals (less than 3%), 20 of these in Bangladesh, did not provide NCD services according to the survey. If these particular facilities were missing data for particular medications or equipment, we assumed the medications or equipment were unavailable. The availability of the essential sets of equipment and medications and their component items were tabulated by geographic units (both by country and by subnational units within countries). We also compared the proportion of facilities that reported diagnosing and managing chronic respiratory diseases, cardiovascular diseases, and diabetes with the availability of essential equipment and medications for asthma, diabetes, hypertension, heart failure, and rheumatic heart disease at those same facilities. We reported 95% confidence intervals (CI) for estimates using standard survey tabulation methods for countries that surveyed a sample of public first-referral hospitals (Bangladesh and the DRC) but not for countries where surveys were intended as a facility census. The surveys from Bangladesh and the DRC sampled a relatively large proportion of the total number of hospitals, so we calculated the 95% CI incorporating a correction for finite population size.

Table 1. **Assigned essential equipment and medications for acute presentations of and chronic care for NCDI conditions at first-referral level hospitals**

Disease Area	Essential Equipment and Medications	
	Acute Care	Chronic Care
Asthma	Pulse oximeter, peak flow meter, oxygen, x-ray, salbutamol inhaler, prednisolone, hydrocortisone injection, nebulizer	Stethoscope, salbutamol inhaler, beclomethasone inhaler, prednisolone
Hypertension (Stage 1 or 2)		Blood pressure apparatus, stethoscope, at least two classes of anti-hypertensive medications (calcium channel blocker, ACE inhibitor, thiazide diuretic, or beta blocker)
Hypertension requiring 3 anti-hypertensive classes		Essential equipment and medications for hypertension stage 1 or 2 (above), one additional class of anti-hypertensive medications
Hypertension requiring 4 anti-hypertensive classes		Essential equipment and medications for hypertension stage 1 or 2 (above), two additional class of anti-hypertensive medications
Heart Failure		Adult weighing scale, stethoscope, blood pressure apparatus, ACE inhibitor, beta-blocker, furosemide, ultrasound*
Rheumatic Heart Disease		Essential equipment and medications for heart failure (above), oral penicillin or benzathine penicillin injection, epinephrine injection
Diabetes Type 1	Blood pressure apparatus, serum blood glucose test, renal function testing, intravenous saline, infusion kit for IV fluids, insulin, glucose injection solution	Serum glucose, insulin
Diabetes Type 2		Serum glucose, metformin or glibenclamide
Epilepsy	Diazepam injectable	Diazepam tablet or phenobarbitone or carbamazepine**
Injury / Surgical Care	Needle holder, scalpel handle and blades, retractor, surgical scissors, nasogastric tube, tourniquet, oxygen, skin disinfectant, suture, ketamine, lidocaine (5%)	
Pain Care		Oral morphine, injectable morphine or injectable pethidine, one non-opioid analgesic (paracetamol, ibuprofen, aspirin, or diclofenac)

*We did not make a determination about whether the appropriate ultrasound probes were available for heart failure diagnostic purposes, only whether there was any functional ultrasound machine. **Epilepsy chronic care not included in results—availability of tablets not included on survey in most countries.

To examine a potential association between the availability of NCDI medications and equipment with the prevalence of extreme poverty in sub-national regions, we used a modified version of the Multidimensional Poverty Index from the Oxford Poverty and Human Development Initiative (Appendix Tables 3 & 4).[8] We counted the number of the individual components across our disease-related sets of medications and equipment (Table 1) that were available at each facility, de-duplicating items in multiple sets. We assessed the association between the logit-transformed proportion of the total items available in a public first-referral level hospital and the prevalence of extreme poverty in the subnational unit (district or region) where the hospital was located using linear regression. We conducted regressions separately for each country to account for likely differences in governance and health systems. We used different regression specifications to assess the association between the availability of equipment and medications and the prevalence of extreme poverty. In one model specification, we used the prevalence of extreme poverty as a continuous variable, assuming a linear association. For possible nonlinear association, we additionally used model specifications categorizing extreme poverty prevalence into categorical groups by quartiles and by evenly spaced ranges of prevalence in each country. We also examined the association between the density of public first-referral level hospitals and hospitals per population in subnational areas with the prevalence of extreme poverty using linear regressions, accounting for country differences. Full details for these analyses are described in the appendix.

Data cleaning, formatting, and preparation were conducted using Stata/IC 15.1 (StataCorp, College Station, Texas), and tabulations and regressions were conducted using R version 3.5.1 (the R Foundation for Statistical Computing).

Results

Overall, of the 9,375 heath facilities across the eight countries which were surveyed, we identified 797 public first-referral level hospitals. Table 2 shows the availability of sets of equipment and medications for condition-specific acute care services, including surgery. The availability at these facilities of the complete set of essential equipment and medications needed for diagnosis and chronic care of specific conditions is shown in Table 3.

243 ***Table 2.*** **Availability of complete essential equipment and medications for acute presentations of**
244 **NCDIs at public first-referral level hospitals in eight low-income countries**

245

	Percent of Facilities with Available Medications and Equipment, % (95% CI)							
	Bangladesh (n=140)	**The Democratic Republic of the Congo† (n=283)**	**Ethiopia (n=117)**	**Haiti (n=25)**	**Malawi (n=43)**	**Nepal (n=76)**	**Senegal‡ (n=37)**	**Tanzania (n=76)**
Acute Asthma	0 (0,3)	1 (1,2)	0	0	0	4	0	0
Functional X-Ray Machine	24 (17,31)	31 (29,33)	64	52	51	86	78	70
Hydrocortisone Injection	47 (39,54)	82 (81,84)	68	52	26	78	67	80
Micronebulizer in NCD or General Outpatient Area	59 (52,67)	6 (5,7)	6	20	21	37	54	4
Oxygen Availability (cylinder or concentrator, plus distribution) in NCD or General Outpatient Area	54 (47,62)	10 (9,11)	14	28	12	12	46	4
Peak Flow Meter in NCD or General Outpatient Area	25 (19,33)	3 (2,4)	8	16	5	30	33	7
Prednisolone	20 (14,27)	50 (47,53)	89	52	77	50	0	76
Pulse Oximeter in NCD or General Outpatient Area	29 (22,36)	11 (9,13)	14	8	21	30	52	11
Salbutamol Inhaler	19 (14,26)	38 (35,41)	82	48	58	91	48	33
Acute Diabetes	0 (0,3)	6 (5,7)	5	4	26	0	0	17
Blood Glucose Test Equipment	27 (21,34)	77 (75,79)	85	40	56	20	9	63
Blood Pressure Apparatus in NCD or General Outpatient Area	99 (93,100)	98 (98,99)	95	96	79	97	87	84
Infusion Kit for IV Fluids in NCD or General Outpatient Area	57 (49,64)	45 (43,48)	34	32	81	38	8	70
Injectable Glucose	11 (7,18)	70 (67,73)	24	40	98	92	91	62
Injectable Saline Solution	72 (64,78)	69 (67,72)	96	52	91	95	82	92
Insulin	1 (0,4)	48 (46,51)	79	12	58	12	51	89
Liver and Kidney Function Diagnostics (Creatinine, Electrolytes)	11 (7,17)	24 (22,26)	47	60	40	38	93	74
Acute Epilepsy	49 (42,57)	81 (78,82)	91	40	95	72	85	91
Diazepam Injection	49 (42,57)	81 (78,82)	91	40	95	72	85	91
Essential Surgical Medications and Equipment*	NA	2 (2,3)	5	0	0	4	2	1
Ketamine in Minor Surgical Area	NA	76 (74,78)	61	20	37	24	3	49
Lidocaine in Minor Surgical Area	NA	80 (77,83)	97	92	95	93	82	99
Nasogastric Tubes in Minor Surgical Area	NA	43 (41,46)	66	40	14	41	23	30
Needle Holder in Minor Surgical Area	NA	98 (97,98)	97	92	100	97	97	95
Oxygen Availability (cylinder or concentrator, plus distribution) in NCD or General Outpatient Area	54 (47,62)	10 (9,11)	14	28	12	12	46	4
Retractor in Minor Surgical Area	NA	85 (84,86)	84	40	44	49	24	41
Scalpel in Minor Surgical Area	NA	86 (83,88)	92	40	74	86	73	78
Skin Disinfectant in Minor Surgical Area	NA	97 (96,97)	99	88	84	95	97	92

Surgical Scissors in Minor Surgical Area	NA	99 (99,99)	97	96	88	95	98	91
Sutures in Minor Surgical Area	NA	85 (83,87)	93	68	93	78	55	92
Tourniquet in Minor Surgical Area	NA	25 (23,27)	54	68	26	67	94	34

NA = No data available or >10% missing data

Numbers reported % (95% confidence interval). Uncertainty not reported for surveys that were intended to include complete census of facilities (all except Bangladesh and the Democratic Republic of the Congo).

†Democratic Republic of the Congo estimates are reported for non-tertiary, non-provincial-level public hospitals

‡Senegal data did not allow for separation of first-referral and higher level hospitals, results reported here for all public hospitals

*Most surgical equipment items are missing data in 5-10% of facilities in Haiti, Malawi, and Senegal. Percentages reported in this table exclude facilities with missing data for a given indicator. Overall percentage of surgical medications and equipment availability unaffected by these missing data, as oxygen unavailable in these missing cases, making overall surgical set unavailable.

Table 3. **Availability of complete essential equipment and medications for chronic care of NCDI conditions at public first-referral level hospitals in eight low-income countries**

	Percent of Facilities with Available Medications and Equipment, % (95% CI)							
	Bangladesh (n=140)	**The Democratic Republic of the Congo† (n=283)**	**Ethiopia (n=117)**	**Haiti (n=25)**	**Malawi (n=43)**	**Nepal (n=76)**	**Senegal‡ (n=37)**	**Tanzania (n=76)**
Asthma	0 (0,3)	1 (1,2)	7	4	5	5	0	0
Beclomethasone Inhaler	5 (2,10)	2 (1,2)	8	8	5	9	3	0
Prednisolone	20 (14,27)	50 (47,53)	89	52	77	50	0	76
Salbutamol Inhaler	19 (14,26)	38 (35,41)	82	48	58	91	48	33
Stethoscope in NCD or General Outpatient Area	100 (98,100)	98 (97,98)	99	96	95	99	83	96
Hypertension (Stage 1 or 2)	31 (24,39)	28 (25,30)	83	76	44	45	38	70
At Least Two of: Calcium Channel Blocker, ACE inhibitor, Thiazide, Atenolol	33 (26,40)	28 (26,30)	89	84	53	46	48	83
Blood Pressure Apparatus in NCD or General Outpatient Area	99 (93,100)	98 (98,99)	95	96	79	97	87	84
Stethoscope in NCD or General Outpatient Area	100 (98,100)	98 (97,98)	99	96	95	99	83	96
Hypertension Requiring 3 Anti-hypertensive Classes	6 (3,12)	9 (8,10)	64	56	26	12	2	51
At Least Three of: Calcium Channel Blocker, ACE inhibitor, Thiazide, Atenolol	8 (5,14)	9 (8,10)	69	60	28	12	2	57
Blood Pressure Apparatus in NCD or General Outpatient Area	99 (93,100)	98 (98,99)	95	96	79	97	87	84
Stethoscope in NCD or General Outpatient Area	100 (98,100)	98 (97,98)	99	96	95	99	83	96
Hypertension Requiring 4 Anti-hypertensive Classes	2 (1,7)	2 (1,3)	34	20	12	0	0	9
All of: Calcium Channel Blocker, ACE inhibitor, Thiazide, Atenolol	3 (1,7)	2 (1,3)	34	20	12	0	0	14
Blood Pressure Apparatus in NCD or General Outpatient Area	99 (93,100)	98 (98,99)	95	96	79	97	87	84
Stethoscope in NCD or General Outpatient Area	100 (98,100)	98 (97,98)	99	96	95	99	83	96
Heart Failure	1 (0,5)	6 (5,7)	26	8	12	0	5	32
Adult Scale in NCD or General Outpatient Area	84 (77,89)	97 (96,97)	71	84	72	95	74	86
Atenolol or other Beta-blocker	55 (47,62)	10 (9,11)	69	56	21	57	5	70
Blood Pressure Apparatus in NCD or General Outpatient Area	99 (93,100)	98 (98,99)	95	96	79	97	87	84
Captopril, Enalapril, or other ACE inhibitor	14 (9,21)	38 (35,40)	80	88	49	0	71	78
Furosemide	22 (16,29)	84 (81,86)	92	64	63	93	86	78
Stethoscope in NCD or General Outpatient Area	100 (98,100)	98 (97,98)	99	96	95	99	83	96
Ultrasound Equipment	5 (2,9)	62 (59,64)	57	52	51	62	8	68
Rheumatic Heart Disease	0 (0,0)	2 (2,3)	19	0	9	NA	0	23

Essential Heart Failure Medications and Equipment	1 (0,5)	6 (5,7)	26	8	12	0	5	32
Benzathine Penicillin	14 (9,21)	53 (50,56)	87	36	100	NA	53	82
Oral Penicillin*	NA	NA	NA	NA	NA	NA	NA	NA
Injectable Epinephrine	2 (1,5)	29 (27,32)	70	8	88	63	56	75
Type 1 Diabetes	1 (0,4)	38 (36,41)	70	8	44	3	5	58
Blood Glucose Test Equipment	27 (21,34)	77 (75,79)	85	40	56	20	9	63
Insulin	1 (0,4)	48 (46,51)	79	12	58	12	51	89
Type 2 Diabetes	9 (5,14)	40 (37,42)	75	32	42	14	3	57
Blood Glucose Test Equipment	27 (21,34)	77 (75,79)	85	40	56	20	9	63
Metformin or Glibenclamide	27 (21,35)	49 (46,51)	86	76	58	61	34	88
Pain Care	NA	NA	NA	NA	58	NA	NA	54
Injectable Morphine or Pethidine	NA	NA	NA	NA	58	NA	NA	54
Oral Pain Medication (Paracetamol, Ibuprofen, Aspirin, or Diclofenac)	100 (97,100)	100 (97,100)	100	100	100	99	NA	100

NA = No data available or >10% missing data
Numbers reported % (95% confidence interval). Uncertainty not reported for surveys that were intended to include complete census of facilities (all except Bangladesh and the Democratic Republic of the Congo).
†Democratic Republic of the Congo estimates are reported for non-tertiary, non-provincial-level public hospitals
‡Senegal data did not allow for separation of first-referral and higher level hospitals, results reported here for all public hospitals
* For oral penicillin, question not asked on most surveys (Tanzania, Senegal, Nepal, Haiti) and high missingness proportion in Bangladesh and Malawi. We therefore do not report proportions here. For creating rheumatic heart disease combined set, it did not affect results, as only 1 facility had missing data for oral penicillin when other necessary components available (heart failure set, epinephrine)

Overall, medication and equipment availability was highest for acute management of epileptic seizures with diazepam (ranging between 40 and 95% in countries), followed by chronic care of stage 1 to 2 hypertension (ranging between 28 and 83%), although this declined with hypertension requiring more classes of medications (ranging between 0 and 34% for 4 classes of medications) (Figure 1). Medication and equipment availability was low both for type 2 diabetes (requiring only oral medications) as well as type 1 diabetes requiring insulin. Availability was particularly low for management of acute presentations of diabetes such as diabetic ketoacidosis requiring intravenous fluids and monitoring of blood chemistries. Availability of essential equipment and medications for both acute and chronic presentations of asthma was extremely low in part due to the absence of beclomethasone inhalers at most facilities. Few hospitals had equipment or medications needed to diagnose and manage heart failure and rheumatic heart disease, which required ultrasound equipment. Essential surgical supplies were missing at most hospitals. Most countries had insufficient data to report on the availability of adequate medications to provide treatment of chronic pain.

Notably, there was much lower observed availability of essential medications or equipment for NCDIs than the self-reported availability of services for these conditions by the facility (Table 4). For chronic respiratory diseases, across six countries (not collected in Bangladesh or Malawi), over 75% of public first-referral hospitals reported diagnosis and management services, though fewer than 7% had the essential medications and equipment available for chronic asthma care and fewer than 4% for care of acute asthma exacerbations. Similarly, at least 66% of public first-referral hospitals in each country reported availability diagnostic and management services for diabetes, with the exceptions of Bangladesh (43%) and Malawi, where diagnosis *or* management was reported in 84% of these hospitals. Compared to this reported service provision, availability of essential medications and equipment were lower for type 1 diabetes (1.3-70.1%), type 2 diabetes (3.3-75.2%), and acute care for diabetic ketoacidosis (0-25.6%). Between 48.8% and 94.3% of the hospitals reported availability of diagnostic and management services for cardiovascular diseases, though availability of essential medications and equipment were lower for hypertension (27.7-82.9%), heart failure (0-31.6%), and rheumatic heart disease (0-22.9%).

Table 4. **Observed equipment and medication availability for selected NCDIs compared to self-reported service availability at public first-referral hospitals**

		Percent of Facilities with Available Medications and Equipment, % (95% CI)							
		Bangladesh (n=140)	**The Democratic Republic of the Congo† (n=283)**	**Ethiopia (n=117)**	**Haiti (n=25)**	**Malawi‡ (n=43)**	**Nepal (n=76)**	**Senegal* (n=37)**	**Tanzania (n=76)**
Self-reported Diagnosis and Management	**Chronic Respiratory Disease**	**NA**	**87 (85,89)**	**95**	**96**	**93‡**	**96**	**92**	**75**
Observed Medication and Equipment Availability	Asthma	0 (0,3)	1 (1,2)	7	4	5	5	0	0
	Asthma Acute Care	0 (0,3)	1 (1,2)	0	0	0	4	0	0
Self-reported Diagnosis and Management	**Diabetes**	**43 (36,51)**	**89 (87,90)**	**83**	**92**	**84‡**	**84**	**86**	**75**
Observed Medication and Equipment Availability	Diabetes Type 1	1 (0,5)	38 (36,41)	70	8	44	3	5	58
	Diabetes Type 2	9 (5,15)	40 (37,42)	75	32	42	14	3	57
	Diabetes Acute Care	0 (0,3)	6 (5,7)	5	4	26	0	0	17
Self-reported Diagnosis and Management	**Cardiovascular Disease**	**49 (41,56)**	**94 (93,95)**	**93**	**92**	**98‡**	**91**	**92**	**73**
Observed Medication and Equipment Availability	Hypertension Stage 1 or 2	31 (24,39)	28 (25,30)	83	76	44	45	38	70
	Heart failure	1 (0,5)	6 (5,7)	26	8	12	0	5	32
	Rheumatic Heart Disease	0 (0,3)	2 (2,3)	19	0	9	NA	0	23

NA = No data available

Numbers reported % (95% confidence interval). Uncertainty not reported for surveys that were intended to include complete census of facilities (all except Bangladesh and the Democratic Republic of the Congo).

†Democratic Republic of the Congo estimates are reported for non-tertiary, non-provincial-level public hospitals

‡Malawi only reported *Diagnosis or management* instead of *Diagnosis and management* for self-reported measures

*Senegal data did not allow for separation of first-referral and higher level hospitals, results reported here for all hospitals

There was inconsistency in associations between availability of medications and equipment in public first-referral hospitals and prevalence of extreme poverty in corresponding sub-national units, both across countries and between regression approaches (appendix Tables 5 and 6). For example, there was a negative association in Bangladesh and the DRC, while there was a positive association in Ethiopia and Haiti. These findings also varied across model specifications. The method for grouping hospitals based on prevalence of extreme poverty in sub-national areas affected the estimates of association. Full regression results are shown in appendix Tables 5 and 6. The density of public first-referral level hospitals per population did not vary by poverty prevalence, though there was evidence that the density of hospitals overall as lower in poorer sub-national areas.

Discussion

Our findings demonstrate that availability of essential equipment and medications for acute and chronic services for NCDI conditions across LICs remains extremely low at public first-referral level hospitals. Furthermore, the availability of essential equipment and medications for NCDI services is much lower than facility-reported management and diagnosis of chronic respiratory diseases, diabetes, and cardiovascular diseases. Although we found some evidence of associations, both positive and negative, between availability of essential equipment and medications at a public first-referral level hospital and the prevalence of extreme poverty in the corresponding sub-national area, results were inconsistent.

Facilities included in this study were more equipped to provide services for the treatment of stage 1 and 2 hypertension as compared to other more complex conditions. Previous facility assessments have demonstrated similar levels of medication availability for HTN treatment in low-income countries,[15,16] and significantly lower availability as compared to high-income countries.[17] The low availability of essential medications and equipment likely contributes to low overall coverage of services for hypertension. The Lancet Commission on Hypertension reported that for countries in sub-Saharan Africa (SSA) with household level surveys, over half of hypertensive adults had not been diagnosed, and treatment coverage was low, ranging from 7-61%.[18] Effective coverage was even lower, ranging from 1-31%.[18]

Systematic reviews of heart failure in LICs have identified a high burden of non-ischemic heart failure and high utilization of diuretic therapy, though have not assessed systems readiness or medication availability.[19,20] One study utilizing a health facility assessment of hospitals in Kenya and Uganda reported higher availability of beta-blockers (98% and 92%, respectively) and furosemide (98% and 94%, respectively), but similar availability of ultrasound equipment and ACE-inhibitors, as compared to that found in our study.[21] The availability of ultrasound has remained a limiting factor for the diagnosis and monitoring of heart failure and has been a focus of health systems diagnostic improvements and training in LICs.[21] Availability of equipment and medications was similarly low for outpatient management of RHD, a common cause of heart failure in LICs. Availability of benzathine penicillin for primary and secondary RHD prophylaxis was highly limited across most countries. Although no detailed health facility reports exist for the availability of benzathine penicillin at primary health facilities across LICs, there have been global concerns for the availability and quality of this essential medication.[22]

Our findings of availability of medications and equipment for diabetes services are consistent with previous reports of low availability of services and low coverage of diabetes services in low-income countries. In a group of 12 countries in SSA, only 22% of eligible individuals had received blood glucose measurement.[23] Of those meeting biochemical criteria for diabetes, only 36% had previously received blood glucose measurement, 27% had been previously diagnosed, 25% were taking oral diabetes therapy, and 11% were taking insulin.[23]

The availability of medications or services for asthma and other chronic respiratory diseases has not been well studied in low-income settings. Inhaled beta agonists, inhaled corticosteroids, and systemic corticosteroids have more recently been included on lists for essential medicines in low-income countries, and price fluctuations have created a wide range of affordability for these medications.[24]

Care for chronic epilepsy has traditionally been lacking in resource-poor settings.[25] Despite the availability of benzodiazepines for acute management of seizures at the inpatient level, the management of chronic epilepsy and seizure prophylaxis is highly lacking. The SPA survey collects information on a limited number of medications that are used for daily prophylaxis of seizures in epileptic disorders and most countries did not include this in their surveys (only Nepal collected data on carbamazepine and phenobarbital). Others

have reported the lack of coverage data, and the highly vulnerable characteristics of patients with epilepsy contribute to poor access to care, utilization of available services, and poor overall coverage, resulting in high morbidity and mortality from epilepsy.[26] The availability of second-line medications or intensive care for refractory seizures was not available.

The extremely low readiness for surgical care of injuries and chronic NCDs is consistent with previous reports. Recent modeling estimates have suggested that coverage of adequate surgical services in SSA and South Asia is less than 5% with sporadic and variable availability of individual tracer items.[27] The ability of surgical interventions to offer one-time curative treatment leads to the high cost-effectiveness and financial risk protection offered by surgical interventions in low-income health systems.[28] Additionally, there is limited data collected in the SPA survey regarding the availability of palliative care services or essential medications, and the data collected was limited only to medications for pain, such as analgesics and opiates. The availability of injectable morphine was collected in only three of the eight countries and availability of oral morphine in only two of the eight countries. This is consistent with the dearth of development in palliative care policies and implementation in low-income countries, particularly in SSA and a dramatic gap in the availability of morphine and other essential medications for palliative care.[29,30]

Countries did vary in their level of availability of essential equipment and medications for the conditions analyzed. Senegal displayed consistently lower rates of availability of equipment and medications than the other countries. In contrast, Ethiopia and Tanzania displayed considerably higher rates than other countries across many conditions, including most notably for hypertension, diabetes care and heart failure. In these two countries there was a relatively early recognition and coordinated approach to NCDs, including strategic and costed operational planning, strong civil society engagement and leadership, progressive outreach from well-established tertiary centers, and a strong and well-organized primary care network.[31,32]

This study has several limitations. First, the essential equipment and medications for NCDI services defined here does not include presence of well-trained and supervised human resources, a cornerstone for healthcare delivery, and one that has been well-established to be lacking for NCDs in SSA.[33] Second, certain equipment and medications may have been observed within the health facility, but these items may not necessarily be accessible to the unit providing NCDI services within the facility (i.e., ultrasound may be

reserved for obstetrics) or affordable by the patients. We minimized this possibility by including equipment and medications from general outpatient, NCD, and minor surgical areas. Additionally, medication availability may fluctuate; however, the date of data collection is randomly assigned and should not bias our findings. Third, the components of these sets of equipment and medications may not be comprehensive of all items needed for care associated with each disease condition, but rather represent a core number of elements measured within the available survey tools. Fourth, availability of supplies and equipment is not always associated with quality care.[34] While there are no data available capturing nationally representative observations of the quality of NCDI services, previous studies in the field of maternal and child health suggest that poor quality care can exist even in the presence of necessary supplies.[35] Fifth, there is some incomplete data for specific disease conditions in certain countries reflecting adaptation of the SPA questionnaire by country teams. Finally, the level of geographical specificity for extreme poverty prevalence estimates limited the design of the analysis examining associations between poverty and the availability of medications and equipment. Further study is warranted, both with more specific data about populations in de facto catchment areas of facilities and process information about how factors like supply chains and planning affects variation in availability across facilities.

Our findings have several implications to improve service availability of NCDIs in LICs. There is a need to prioritize decentralization of a broad set of cost-effective and equitable interventions at first-referral level hospitals to increase care availability. Such interventions may include those typically confined to referral and university teaching hospitals and densely populated urban areas, such as chronic care delivery for severe NCDIs including heart failure, type 1 diabetes, advanced asthma, and palliative care. Our finding that the density of hospitals per population is lower in poorer subnational areas, while the distribution of first-referral hospitals is more equitable, suggests that decentralization of services can create more equitable access. Collaborations to develop such service packages have recently been launched.[36] Several studies have reported promising outcomes for task-shifting and task sharing of essential NCD services to support decentralization and increase availability of such services.[37–39] Integration of NCD services with existing HIV and MCH services has been suggested as a cost-effective and important step towards increasing the availability of services in a universal health coverage (UHC) package, particularly at the primary care level.[40] Coordination of governance and policy making for NCDI health sector interventions would also

provide opportunities for integration of staff, training, guidelines, and supply chains required for adequate service delivery.[41] Health financing for integrated platforms of NCDI service delivery within a UHC framework will be essential to improve basic availability of services. A high priority package for essential interventions for NCDIs within UHC has been proposed, and may provide reasonable cost estimates required to increase coverage of health sector services for NCDIs, including cross-cutting approaches to mental health, surgery, palliative care, and rehabilitation.[5]

The strengthening of health facility monitoring, and extension of core NCDI indicators is highly needed.[42] Although some readiness indices exist within standardized surveys, such as SPA and the Service Availability and Readiness Assessment (World Health Organization), these are typically limited to outpatient management of hypertension, type 2 diabetes, and asthma. These surveys do not measure readiness for acute complications or inpatient needs, rely in part on reported (rather than observed) measures, and do not identify minimum requirements for service delivery. An appropriate monitoring framework for NCDIs will need to include a greater number of tracer items that reflect current clinical guidelines, other NCDI conditions currently not represented in existing monitoring frameworks but represent a large burden of disease (i.e., cancer, epilepsy, mental health, renal failure, liver cirrhosis, palliative care surgical services), and domains such as organization, management, access, availability, and quality of effective services.[43] Additional examination of costing data, procurement processes, and the supply chain could identify the drivers of stockouts.

Our findings demonstrate variable but overall low availability of the minimum required equipment and medications to provide adequate diagnostic and therapeutic interventions for nine chronic conditions and four acute presentations of chronic conditions at first-referral level hospitals in eight LICs in three different regions. This observed availability of medications and equipment is substantially lower than self-reported diagnosis and management of chronic diseases by facilities in these countries. The provision of cost-effective and equitable health sector interventions for the diagnosis and management of both acute and chronic presentations of NCDIs are highly needed at first-referral level hospitals in LICs. The strengthening of these services through the public sector can help keep patients from facing high costs for medicines and procedures. There is a need for progressive decentralization of services for these conditions to first-referral level facilities,

integration of such services in existing platforms of care, and improved assessment and monitoring of delivery of services in LICs to fully achieve targets established for UHC.

Contributors

GB initiated the study. NG, MC, and GB designed the analysis. NG conducted the literature search. AG and MC conducted data cleaning. MC conducted data analysis. NG, MC, and GB drafted the manuscript. All authors contributed to data interpretation and critical evaluation and revision of the study manuscript.

Acknowledgements

The authors would like to thank Gisela Robles Aguilar for estimation of subnational poverty prevalence, as well as Mamka Anyona for assistance with initial data analysis and Chris Noble for support with manuscript preparation. Gene F. Kwan was supported in part from the National Institutes of Health (1K23HL140133).

Funding

This study was funded by the Leona M. and Harry B. Helmsley Charitable Trust

Declaration of interests

We declare no competing interests.

Ethics approval

Ethics approval was not required for this study since it used secondary data, which are available in the public domain. The Institutional Review Board of the Harvard Faculty of Medicine determined this work to be not human subject research requiring additional approval.

Data availability statement

Data from the Service Provision Assessment surveys are available in a public, open access repository through the DHS Program: http://dhsprogram.com/data/available-datasets.cfm.

Patient and Public Involvement

This research was done without patient involvement. Patients were not invited to comment on the study design and were not consulted to develop patient relevant outcomes or interpret the results. Patients were not invited to contribute to the writing or editing of this document for readability or accuracy.

References

1 Kyu HH, Abate D, Abate KH, *et al.* Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet* 2018;**392**:1859–922. doi:10.1016/S0140-6736(18)32335-3

2 Bukhman G, Mocumbi AO, Horton R. Reframing NCDs and injuries for the poorest billion: a Lancet Commission. *The Lancet* 2015;**386**:1221–2.

3 Ogoina D, Onyemelukwe GC. The role of infections in the emergence of non-communicable diseases (NCDs): Compelling needs for novel strategies in the developing world. *Journal of Infection and Public Health* 2009;**2**:14–29. doi:10.1016/j.jiph.2009.02.001

4 Moucheraud C. Service Readiness For Noncommunicable Diseases Was Low In Five Countries In 2013–15. *Health Affairs* 2018;**37**:1321–30. doi:10.1377/hlthaff.2018.0151

5 Jamison DT, Alwan A, Mock CN, *et al.* Universal health coverage and intersectoral action for health: key messages from Disease Control Priorities, 3rd edition. *The Lancet* 2018;**391**:1108–20. doi:10.1016/S0140-6736(17)32906-9

6 WHO Expert Committee on the Role of Hospitals at the First Referral Level & World Health Organization. Hospitals and Health for All: Report of a WHO Expert Committee on the Role of Hospitals at the First Referral Level. World Health Organization Technical Report Series 744. Geneva: : World Health Organization 1987. https://apps.who.int/iris/handle/10665/38113

7 Lerberghe W van, Lafort Y, World Health Organization. The Role of the Hospital in the District: Delivering or supporting primary health care? Geneva: : World Health Organization, Division of Strengthening of Health Services 1990. https://apps.who.int/iris/handle/10665/59744

8 Robles Aguilar G, Sumner A. Who Are the World's Poor? A New Profile of Global Multidimensional Poverty. Working Paper 499. Washington, DC: : Center for Global Development 2019. https://www.cgdev.org/publication/who-are-worlds-poor-new-profile-global-multidimensional-poverty (accessed 23 Jan 2019).

9 Gabrysch S, Campbell OM. Still too far to walk: Literature review of the determinants of delivery service use. *BMC Pregnancy and Childbirth* 2009;**9**:34. doi:10.1186/1471-2393-9-34

10 Sharma J, Leslie HH, Kundu F, *et al.* Poor Quality for Poor Women? Inequities in the Quality of Antenatal and Delivery Care in Kenya. *PLoS One* 2017;**12**. doi:10.1371/journal.pone.0171236

11 Service Provision Assessments (SPA). The DHS Program. https://dhsprogram.com/What-We-Do/Survey-Types/SPA.cfm (accessed 14 Feb 2018).

12 The DHS Program - Survey Search. The DHS Program. https://dhsprogram.com/What-We-Do/survey-search.cfm?pgtype=main&SrvyTp=type (accessed 14 Feb 2018).

13 Kruk ME, Chukwuma A, Mbaruku G, *et al.* Variation in quality of primary-care services in Kenya, Malawi, Namibia, Rwanda, Senegal, Uganda and the United Republic of Tanzania. *Bull World Health Organ* 2017;**95**:408–18. doi:10.2471/BLT.16.175869

14 Gage AD, Leslie HH, Bitton A, *et al.* Assessing the quality of primary care in Haiti. *Bull World Health Organ* 2017;**95**:182–90. doi:10.2471/BLT.16.179846

15 Peck R, Mghamba J, Vanobberghen F, *et al.* Preparedness of Tanzanian health facilities for outpatient primary care of hypertension and diabetes: a cross-sectional survey. *Lancet Glob Health* 2014;**2**:e285–92. doi:10.1016/S2214-109X(14)70033-6

16 Mendis S, Al Bashir I, Dissanayake L, *et al.* Gaps in capacity in primary care in low-resource settings for implementation of essential noncommunicable disease interventions. *Int J Hypertens* 2012;**2012**:584041. doi:10.1155/2012/584041

17 van Mourik MSM, Cameron A, Ewen M, *et al.* Availability, price and affordability of cardiovascular medicines: a comparison across 36 countries using WHO/HAI data. *BMC Cardiovasc Disord* 2010;**10**:25. doi:10.1186/1471-2261-10-25

18 Olsen MH, Angell SY, Asma S, *et al.* A call to action and a lifecourse strategy to address the global burden of raised blood pressure on current and future generations: the Lancet Commission on hypertension. *Lancet* 2016;**388**:2665–712. doi:10.1016/S0140-6736(16)31134-5

19 Damasceno A, Mayosi BM, Sani M, *et al.* The causes, treatment, and outcome of acute heart failure in 1006 Africans from 9 countries. *Arch Intern Med* 2012;**172**:1386–94. doi:10.1001/archinternmed.2012.3310

20 Callender T, Woodward M, Roth G, *et al.* Heart failure care in low- and middle-income countries: a systematic review and meta-analysis. *PLoS Med* 2014;**11**:e1001699. doi:10.1371/journal.pmed.1001699

21 Carlson S, Duber HC, Achan J, *et al.* Capacity for diagnosis and treatment of heart failure in sub-Saharan Africa. *Heart* 2017;**103**:1874–9. doi:10.1136/heartjnl-2016-310913

22 Wyber R, Taubert K, Marko S, *et al.* Benzathine Penicillin G for the Management of RHD: Concerns About Quality and Access, and Opportunities for Intervention and Improvement. *Glob Heart* 2013;**8**:227–34. doi:10.1016/j.gheart.2013.08.011

23 Manne-Goehler J, Atun R, Stokes A, *et al.* Diabetes diagnosis and care in sub-Saharan Africa: pooled analysis of individual data from 12 countries. *Lancet Diabetes Endocrinol* 2016;**4**:903–12. doi:10.1016/S2213-8587(16)30181-4

24 Babar Z-U-D, Lessing C, Mace C, *et al.* The availability, pricing and affordability of three essential asthma medicines in 52 low- and middle-income countries. *Pharmacoeconomics* 2013;**31**:1063–82. doi:10.1007/s40273-013-0095-9

25 Meyer A-C, Dua T, Ma J, *et al.* Global disparities in the epilepsy treatment gap: a systematic review. *Bull World Health Organ* 2010;**88**:260–6. doi:10.2471/BLT.09.064147

26 Ba-Diop A, Marin B, Druet-Cabanac M, *et al.* Epidemiology, causes, and treatment of epilepsy in sub-Saharan Africa. *Lancet Neurol* 2014;**13**:1029–44. doi:10.1016/S1474-4422(14)70114-0

27 Alkire BC, Raykar NP, Shrime MG, *et al.* Global access to surgical care: a modelling study. *Lancet Glob Health* 2015;**3**:e316-323. doi:10.1016/S2214-109X(15)70115-4

28 Meara JG, Leather AJM, Hagander L, *et al.* Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *The Lancet* 2015;**386**:569–624.

29 Rhee JY, Garralda E, Torrado C, *et al.* Palliative care in Africa: a scoping review from 2005-16. *Lancet Oncol* 2017;**18**:e522–31. doi:10.1016/S1470-2045(17)30420-5

30 Knaul FM, Farmer PE, Krakauer EL, *et al.* Alleviating the access abyss in palliative care and pain relief-an imperative of universal health coverage: the Lancet Commission report. *Lancet* 2018;**391**:1391–454. doi:10.1016/S0140-6736(17)32513-8

31 Ministry of Health, Community Development, Gender, Elderly and Children, Government of the United Republic of Tanzania. Strategic plan and action plan for the prevention and control of non communciable diseases in Tanzania 2016-2020. 2016.https://extranet.who.int/ncdccs/Data/TZA_B3_NCD%20Stategic%20Plan%202016%20-%202020v0.3.pdf (accessed 14 Feb 2018).

32 Ministry of Health, Federal Democratic Republic of Ethiopia. National strategic action plan (NSAP) for prevention & control of non-communicable diseases in Ethiopia: 2014-2016. Addis Ababa, Ethiopia: : Ministry of Health, Federal Democratic Republic of Ethiopia https://www.iccp-portal.org/system/files/plans/ETH_B3_National%20Strategic%20Action%20Plan%20%28NSAP%29%20for%20Prevention%20and%20Control%20of%20Non-Communicable%20Diseases%20-%20Final.pdf (accessed 14 Feb 2018).

33 World Health Organization. Health workforce requirements for Universal Health Coverage and the Sustainable Development Goals. 2016.https://www.who.int/hrh/resources/health-observer17/en/ (accessed 14 Feb 2018).

34 Leslie HH, Sun Z, Kruk ME. Association between infrastructure and observed quality of care in 4 healthcare services: A cross-sectional study of 4,300 facilities in 8 countries. *PLOS Medicine* 2017;**14**:e1002464. doi:10.1371/journal.pmed.1002464

35 Kruk ME, Gage AD, Arsenault C, *et al.* High-quality health systems in the Sustainable Development Goals era: time for a revolution. *The Lancet Global Health* 2018;**6**:e1196–252. doi:10.1016/S2214-109X(18)30386-3

36 WHO Regional Office for Africa. PEN-Plus Meeting in Kigali – The management and treatment of non-communicable diseases at primary levels strengthened. https://www.afro.who.int/news/pen-plus-meeting-kigali-management-and-treatment-non-communicable-diseases-primary-levels (accessed 16 Sep 2019).

37 Joshi R, Alim M, Kengne AP, *et al.* Task shifting for non-communicable disease management in low and middle income countries--a systematic review. *PLoS ONE* 2014;**9**:e103754. doi:10.1371/journal.pone.0103754

38 Anand TN, Joseph LM, Geetha AV, *et al.* Task sharing with non-physician health-care workers for management of blood pressure in low-income and middle-income countries: a systematic review and meta-analysis. *The Lancet Global Health* 2019;**7**:e761–71. doi:10.1016/S2214-109X(19)30077-4

39 Eberly LA, Rusingiza E, Park PH, *et al.* 10-Year Heart Failure Outcomes From Nurse-Driven Clinics in Rural Sub-Saharan Africa. *Journal of the American College of Cardiology* 2019;**73**:977–80. doi:10.1016/j.jacc.2018.12.028

40 Atun R, Jaffar S, Nishtar S, *et al.* Improving responsiveness of health systems to non-communicable diseases. *The Lancet* 2013;**381**:690–7. doi:10.1016/S0140-6736(13)60063-X

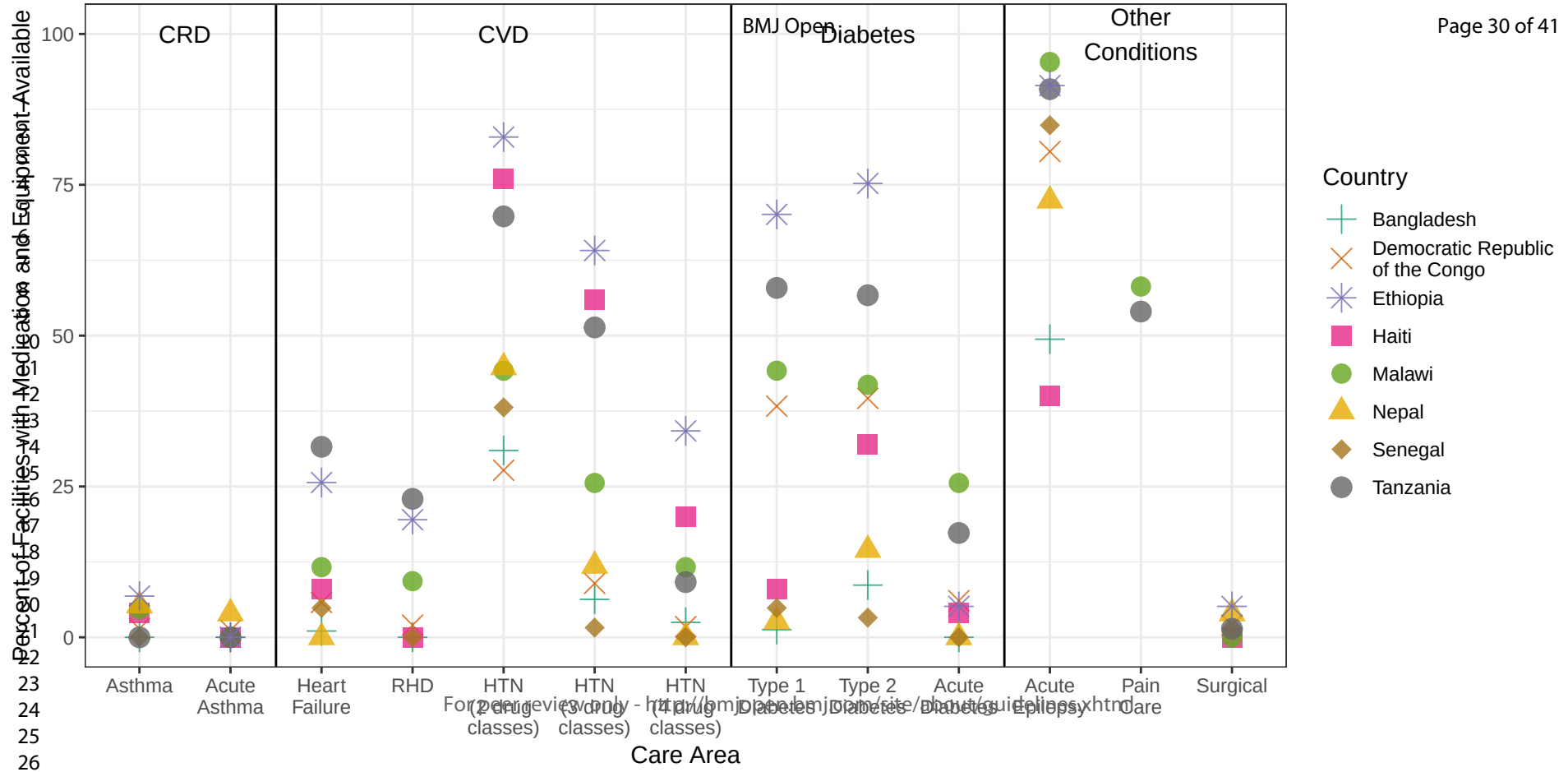
41 Gupta N, Bukhman G. Leveraging the lessons learned from HIV/AIDS for coordinated chronic care delivery in resource-poor settings. *Healthc (Amst)* 2015;**3**:215–20. doi:10.1016/j.hjdsi.2015.09.006

42 Nickerson JW, Adams O, Attaran A, *et al.* Monitoring the ability to deliver care in low- and middle-income countries: a systematic review of health facility assessment tools. *Health Policy Plan* 2015;**30**:675–86. doi:10.1093/heapol/czu043

43 Primary Health Care Performance Initiative (PHCPI). PHCPI. 2018.https://improvingphc.org/ (accessed 20 May 2019).

Figure 1. **Availability of complete essential equipment and medications for acute presentations and chronic care of NCDI conditions at public first-referral level hospitals in eight low-income countries**

CRD=Chronic respiratory disease, CVD=Cardiovascular disease, RHD=Rheumatic heart disease, HTN=Hypertension



Supplementary appendix

***Appendix Table 1*: Summary of Service Provision Assessments and facilities included in data analysis**

	Facilities Included in Analysis	Census or Sample of First-Referral Hospitals	Number of Surveyed Public Hospitals of Selected Level	Number of Surveyed Private Hospitals of Selected Level	Facilities not Surveyed of Selected Level	Number of Total Hospitals of Level of Interest in the Country, Private and Public (from SPA report)	Population[1]	Implied Catchment Size for Public and Private Facilities at Selected Level (facilities/population)	Catchment Size Described in Report
Bangladesh (2014)[2]	Public upazila health complexes	Sample	140	0	285	425 upazila health complexes, 53 district hospitals	159,405,279 (2014)	Upazila health complexes (375,000), district hospitals (3 million)	Not described
The Democratic Republic of the Congo (2017-18)[3]	Public non-tertiary, non-provincial hospitals	Sample (includes >90% of general referral hospitals)	283	200	491 of 524 general referral hospitals selected for sample*	524 referral hospitals (includes tertiary/provincial/national, report does not separate)	84,004,989 (2018)	All referral hospitals (160,000), non-tertiary/provincial referral hospitals (~165,000-175,000)	Not described
Ethiopia (2014)[4]	Public primary hospitals and general hospitals	Census	117	65	8	56 primary hospitals, 134 general hospitals	97,366,774 (2014)	Primary hospitals (1.7 million), General hospitals (727,000), Combined (512,000)	Targets: Primary hospital (60,000-100,000), General hospital (1-1.5 million)
Haiti (2013)[5]	Public community referral hospitals	Census	25	15	**	121 hospitals (includes other types, report does not separate), 40 community referral hospitals in dataset (census)	10,431,776 (2013)	Community referral hospitals (261,000)	Not described
Malawi (2013)[6]	Public district hospitals and rural/community hospitals	Census	43	22	**	119 hospitals (includes other types of hospitals, report does not separate); 65 district and rural/community hospitals in dataset (census)	16,577,147 (2013)	District and rural/community hospitals combined (255,000)	Not described
Nepal (2015)[7]	Public district hospitals	Census	76	0	0	76 district hospitals	28,656,282 (2015)	District hospitals (377,000)	Not described

Senegal (2016-17)[8]	Public hospitals	Continuous SPA, essentially a census with 2 combined years	37	33	***	68 hospitals	15,850,567 (2017)	Hospitals (233,000)	Public hospitals (423,000)
Tanzania (2014-15)[9]	Public district hospitals and district designated hospitals	Census	76	20	**	265 hospitals (includes other types of hospitals, report does not separate); 96 district and district designated hospitals in dataset (census)	53,879,957 (2015)	District hospitals and district designated hospitals (561,000)	Not described

*Calculation not possible with facility types in report table—some of the 524 hospitals include tertiary/provincial hospitals
**Calculation not possible with facility types in report table, but total number in dataset should be close to total since hospital sample was census
***Calculation not possible with Senegal survey combined from two years, but should be close to facility census combining the surveys

For 95% confidence intervals for estimates from countries without censuses of facilities, we used finite population corrections. In Bangladesh, we knew that there were 425 total facilities of interest, of which 140 were surveyed, so we corrected using 425 as the total population. In the DRC, tables in the SPA report gave total numbers of general referral hospitals but not the specific type of interest to us. The dataset allowed us to exclude tertiary/provincial hospitals, but we were not able to obtain the exact number of public first-referral hospitals. In the sample, there were 283 hospitals we included in the analysis. We know that 491 out of 524 hospitals (including private) were selected for the sample, so 33 were not included. Conservatively, no more than 316 (283+33) facilities could be in the population of hospitals of interest. We used this number for the finite population correction as a conservative cap (confidence intervals are therefore conservatively large.

***Appendix Table 2*: Variables excluded from Service Provision Assessment surveys or with >10% missing data, by country**

Country	Variables not included in survey	Variables with >10% missing data
Bangladesh	All surgical equipment, oral morphine	Oral penicillin, injectable morphine, injectable pethidine
The Democratic Republic of the Congo	Injectable morphine/pethidine, oral morphine	
Ethiopia	Oral penicillin, oral morphine	
Haiti	Oral penicillin, injectable morphine/pethidine, oral morphine	Some surgical equipment
Malawi	-	Oral penicillin
Nepal	Oral penicillin, benzathine penicillin, injectable morphine/pethidine, oral morphine	
Senegal	Oral penicillin, injectable morphine/pethidine, oral morphine	Analgesics
Tanzania	Oral penicillin	Oral morphine

*variables asked in only one country include: phenobarbitone tablets (Nepal), diazepam tablets (Bangladesh), carbamazepine tablets (Nepal)

Appendix Table 3: **Indicators in modified Multi-dimensional Poverty Index**

Dimension	Indicator	Deprivation cut-off
Education	Schooling	No household member has completed five years of schooling
	Attendance	Any school-aged child in the household is not attending school up to class 8
Standard of living	Electricity	The household has no electricity
	Sanitation	The household's sanitation facility is not improved or it is shared with other households
	Water	The household does not have access to safe drinking water or safe water is more than a 30-minute walk, round trip
	Floor	The household has a dirt, sand, or dung floor
	Cooking fuel	The household cooks with dung, wood, or charcoal
	Assets	The household does not own more than one of the following: radio, TV, telephone, bike, motorbike, or refrigerator; however, if the household owns a car or truck, they do not count as deprived in this category

***Appendix Table 4*: Source of data for Multi-dimensional Poverty Index, by country**

Country	**Poverty Index Survey**
Bangladesh	DHS 2014
The Democratic Republic of the Congo	DHS 2013-14
Ethiopia	DHS 2011*
Haiti	DHS 2012*
Malawi	DHS 2015-16
Nepal	MICS 2014
Senegal	DHS 2015*
Tanzania	DHS 2015-16

*More recent DHS 2016 available. Estimates do not reflect these new datasets.
Differences in year between poverty and SPA surveys in each country are 3 years or fewer (DRC 3-4 years)

Subnational poverty, hospital density, and availability of services.

Poverty and service availability

We defined the prevalence of extreme poverty using a modified version of the Multidimensional Poverty Index.[10] We defined extreme poverty using 5 of 8 deprivations (Appendix Table 3). Using household survey data from recent surveys (Appendix Table 4), we found the proportion of the population in districts or regions that met this definition of extreme poverty.

To assess whether there might be an association between poverty prevalence in the subnational areas in which hospitals are located and the availability of medications and equipment at these hospitals, we conducted country-specific regressions using two different specification strategies.

In our construction of the sets of medication and equipment, there was information loss because the absence of one item made the whole set unavailable. To include this information in our assessment of the possible association between poverty and availability of medications and equipment, we included each of the individual items that are part of the various disease-specific sets (main text Table 1), deduplicating the items contained in multiple sets. We calculated the percent of the total items available at each facility. This proportion, transformed to logit space, was the outcome in both of our regression specifications.

In the first regression specification, we regressed the logit-transformed proportion of total items available in hospitals (h) on the proportion of population living in poverty (*% Pop Poverty*) in the subnational area (region or district) where the hospital is located. We conducted a separate regression for each country because we anticipated different associations were possible in different countries based on differences in health systems across countries.

$$Logit(\%\ Items\ Available)_{c,h} = \beta_{1,c} + \beta_{2,c} * \%\ Pop\ Poverty_{c,h} + \ \varepsilon_{c,h}$$

The second specification allowed for nonlinear associations between the two variables. We created bins of facilities, grouped using cutoffs in the poverty prevalence variable. To illustrate, in a country where hospitals were binned into four groups based on poverty prevalence, the groups would be included as "dummy" variables (I) as follows, where I_2, I_3, and I_4 represent the second two groups, while the first group is the reference group.

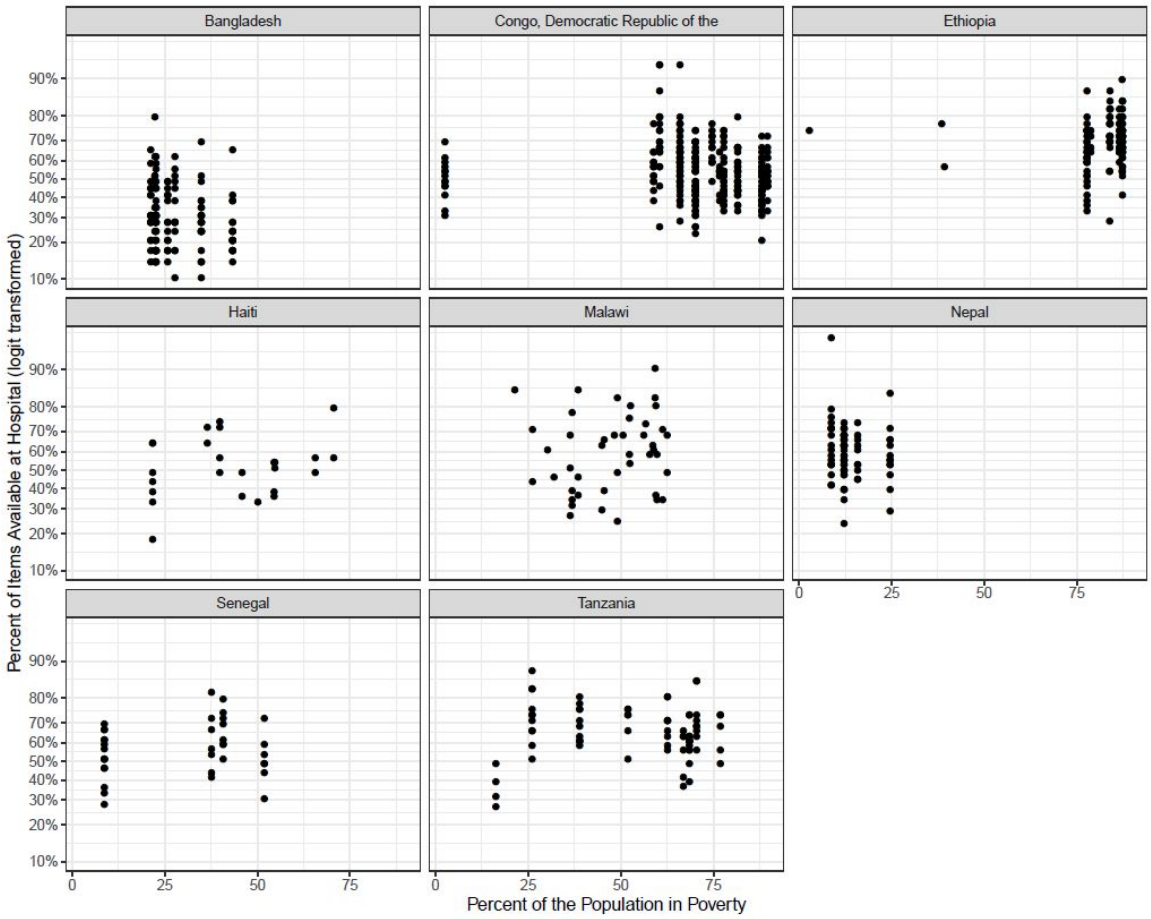
$$Logit(\%\ Items\ Available)_{c,h} = \beta_{1,c} + \beta_{2,c} * I_{2,c,h} + \beta_{3,c} * I_{3,c,h} + \beta_{4,c} * I_{4,c,h} + \ \varepsilon_{c,h}$$

We did two sets of regressions using groups created in two different ways—based on the quartiles of poverty prevalence and based on dividing the poverty prevalence range of the subnational units in the country into four categories evenly spaced on the scale of poverty prevalence. To create the first category, we ranked the hospitals by poverty prevalence in the corresponding subnational unit and calculated the cumulative proportion of hospitals. We split groups based on the cumulative proportions closest to 25%, 50%, and 75%. To create the second category, we subtracted the poverty prevalence in the lowest-poverty area from the poverty prevalence in the highest-poverty area. We then divided this range into four even parts and assigned hospitals to the four groups using the poverty prevalence in the subnational unit corresponding to the hospital. Sometimes, one of the parts of the range did not contain any of the public first-referral level hospitals. For instance, in Ethiopia, the ranges were approximately 2.8-23.925%, 23.925-45.05%, 45.05-66.175%, and 66.175-87.3%, but there were no subnational units with between 45.05% and 66.175% poverty prevalence. In cases with no subnational units in a particular quartile, the model simply had fewer categories. Ranges in the other countries were as follows: Bangladesh (22.1-26.725%, 26.725-32.25%, 32.25-37.775%, and 37.775-43.3%), DRC (2.6-24.35%, 24.35-46.1%, 46.1-67.85%, and 67.85-89.6%), Haiti (21.7-33.925%, 33.925-46.15%, 46.15-58.375%, and 58.375-70.6%), Malawi (21.4-31.675%, 31.675-41.95%, 41.95-52.225%, and 52.225-62.5%), Nepal (8.7-12.69167%, 12.69167-16.65%, 16.65-20.60833%, and 20.60833-24.56667%), Senegal (8.7-19.5%, 19.5-30.3%, 30.3-41.1%, and 41.1-51.9%), and Tanzania (16.3-31.45%, 31.45-46.6%, 46.6-61.75%, and 61.75-76.9%).

Scatter plots of the percent of items available and the percent of the population in poverty are found in Appendix Figure 1. Points on a vertical line indicate facilities located within the same subnational unit. While

some subnational units do visually appear to have different average availability than others, there is relatively little visual evidence of systematic trends in availability with respect to poverty. Results from the first regression specification are in Appendix Table 5. There was a significant association in the Democratic Republic of the Congo ($p < 0.05$) and an association that would meet looser criteria for significance in Bangladesh ($p < 0.1$). The degree of the associations were not too large—they implied differences of 8 percentage points between the lowest-poverty (2.6%) and highest-poverty (89.6%) units in the Democratic Republic of the Congo and 6 percentage points between the lowest-poverty (21.2%) and highest-poverty (43.3%) units in Bangladesh, for instance, corresponding to roughly two to four of the 41 items included in creating the proportions. The regression coefficients on the poverty term were insignificant in the other countries and their point estimates were positive, rather than negative, in all but Nepal.

***Appendix Figure 1*: Percent of medication and equipment items available in hospitals and percent of the population living in poverty in the region or district of the hospitals, by country**



***Appendix Table 5*: Regression results for association between availability of medications and equipment at public first-referral level hospitals and poverty in corresponding subnational unit, specification 1**

Country	Intercept β (SE)	Logit Poverty Proportion β (SE)
Bangladesh	-0.46103 (0.21740)†	-0.01428 (0.00743)*
Democratic Republic of the Congo	0.44823 (0.14464) ‡	-0.00393 (0.00196)†
Ethiopia	0.43452 (0.41700)	0.00457 (0.00502)
Haiti	-0.30321 (0.36910)	0.00866 (0.00806)
Malawi	-0.05541 (0.55816)	0.00914 (0.01145)

Nepal	0.57292 (0.19222)‡	-0.01375 (0.01287)
Senegal	0.10679 (0.18376)	0.00560 (0.00538)
Tanzania	0.61029 (0.20044)‡	0.00048 (0.00351)

*p < 0.1, †p < 0.05, ‡p < 0.01

The second set of results, using regressions with hospitals grouped based on ranges of poverty prevalence, gave results that were similar in some ways but differed in others. The quartile regression found lower availability in the highest-poverty quartile in Bangladesh ($p < 0.05$), while the regression based on the ranges found that the hospitals in the highest poverty range showed lower availability under weaker criteria for significance ($p < 0.1$). In the Democratic Republic of the Congo, the selection of bins made a large difference in interpretation. Using quintiles showed lower availability in hospitals in the poverty quintiles above the first, while using ranges found higher availability in the third range compared to the first. The plot showed a downward trend in availability with poverty in the units with poverty over 50%, but the subnational unit with very low poverty created an odd distribution. Similarly, in Ethiopia, the range was made large by few hospitals in low-poverty areas, but the specification using quartiles found higher availability in higher-poverty quartiles ($p < 0.01$). In Haiti, both methods, but particularly the quartile method, suggested higher availability in hospitals in higher-poverty areas. Both methods showed higher availability in the third group in Senegal. No association was found in Malawi, Nepal, or Tanzania.

While both the continuous and binned specifications suggested lower availability in higher-poverty subnational units in Bangladesh and the Democratic Republic of the Congo, the story appears more complex. The trend in Congo appears to be mostly among the subnational units in higher-poverty areas rather than compared to the hospitals in the low-poverty area, evidenced by Appendix Figure 1 and the differing results from the bins using the range method rather than the quartile method. Additionally, the binned methods suggested availability was higher in high-poverty areas in Haiti and Ethiopia, though somewhat inconsistently between the two binning methods.

From this analysis, we can conclude that there is some evidence for differences in availability of medications and equipment across public first-referral level hospitals that may correlate with poverty, though not in a consistent manner across countries or across methods of evaluation. There appear to be both positive and negative correlations in different locations. More detailed data, for example, relating to poverty in specific facility catchment areas, would be necessary to make nuanced claims about inequities in availability of medications and equipment. There is variation in availability within subnational units (points oriented vertically in Appendix Figure 1), which means that facility catchment area factors, for example, could correlate with availability. Further, to understand the drivers of any patterns, more complex administrative data, for instance on supply chains and procurement, would be necessary.

Poverty and hospital density per population

Another factor contributing to inequitable access to care for individuals and families living in poverty is geographic access to health facilities. The density of health facilities tends to be higher in urban areas for many reasons, including availability of human resources and proximity to larger populations. We tested whether the density of hospitals per population in subnational areas was associated with the prevalence of extreme poverty, both for public first-referral level hospitals and hospitals overall. We excluded Bangladesh and the Democratic Republic of the Congo from this analysis. The survey in Bangladesh did not contain a census of first-referral level hospitals, and the survey in the Democratic Republic of the Congo was not as close to a complete census as the surveys in the other countries. We totaled the number of first-referral level and overall hospitals per subnational area, and calculated the density of hospitals per population. We hypothesized that the density of public first-referral level hospitals per population in a subnational area would not be associated with subnational poverty because governments tend to distribute these hospitals to have relatively consistent catchment areas and to cover the whole population. We hypothesized that the density of hospitals overall in a subnational area would be lower in subnational areas with higher poverty because hospitals tend to be more concentrated in large urban areas, which tend to have lower poverty prevalence than rural areas. We regressed the hospital density per capita in each subnational area (s) on the proportion of the population in extreme poverty, pooling countries (c) and including a set of country indicators (I) to account for country differences in overall density of facilities.

$$Hospitals\ per\ population_{c,s} = \beta_1 + \beta_2 * \%\ Pop\ Poverty_{c,s} + \beta_{3-7} * I_c + \varepsilon_c$$

We also tested a specification including the log of the subnational population in the subnational area as a predictor, as one might expect high-population areas to have a greater density of hospitals because of concentration of resources in large urban centers.

We found no association between the density of public first-referral level hospitals per population and poverty prevalence. Meanwhile, the density of hospitals per population overall was lower in higher-poverty areas ($p < 0.01$). The log of the population was a significant predictor, but its inclusion did not substantially change the results. These findings are consistent with our hypothesis that the density of public first-referral level hospitals is relatively consistent with respect to poverty prevalence but that hospitals overall are more common in higher-population, lower-poverty areas. These findings reinforce that availability of services at public first-referral level hospitals is important for equity, as these facilities are more evenly distributed with respect to poverty prevalence. However, these findings do not incorporate information about other aspects of accessibility including travel time, distance, or fees, for example.

***Appendix Table 6*: Regression results for association between availability of medications and equipment at public first-referral level hospitals and poverty in corresponding subnational unit, specification 2**

Country	Hospitals Grouped in Quartiles		Hospitals Grouped in Even % Ranges	
Bangladesh				
	Intercept β (SE)	-0.62287 (0.11719) ‡	Intercept β (SE)	-0.80940 (0.07400) ‡
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	-0.30865 (0.16214)*	R2 β (SE)	0.07353 (0.19378)
	Q3 β (SE)	-0.20948 (0.16996)	R3 β (SE)	-0.12964 (0.15309)
	Q4 β (SE)	-0.38529 (0.15402) †	R4 β (SE)	-0.28969 (0.17061)*
Democratic Republic of the Congo				
	Intercept β (SE)	0.43720 (0.06017) ‡	Intercept β (SE)	-0.00119 (0.15268)
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	-0.41962 (0.10040) ‡	R2 β (SE)	ND
	Q3 β (SE)	-0.26806 (0.08826) ‡	R3 β (SE)	0.51809 (0.16598) ‡
	Q4 β (SE)	-0.54222 (0.09452) ‡	R4 β (SE)	0.04153 (0.15815)
Ethiopia				
	Intercept β (SE)	0.51980 (0.09484) ‡	Intercept β (SE)	1.06471 (0.55630)*
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	0.47039 (0.13900) ‡	R2 β (SE)	-0.33381 (0.68133)
	Q3 β (SE)	0.40906 (0.15384) ‡	R3 β (SE)	ND
	Q4 β (SE)	0.33925 (0.12635) ‡	R4 β (SE)	-0.25477 (0.55874)
Haiti				
	Intercept β (SE)	-0.26178 (0.20445)	Intercept β (SE)	-0.26178 (0.22762)
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	0.88173 (0.30094) ‡	R2 β (SE)	0.64785 (0.31168)*
	Q3 β (SE)	-0.10821 (0.30094)	R3 β (SE)	0.03122 (0.33505)
	Q4 β (SE)	0.59917 (0.30094)*	R4 β (SE)	0.71651 (0.37747)*
Malawi				
	Intercept β (SE)	0.31416 (0.29877)	Intercept β (SE)	0.71179 (0.41719)*
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	-0.21344 (0.36996)	R2 β (SE)	-0.69985 (0.48718)
	Q3 β (SE)	0.40502 (0.41061)	R3 β (SE)	-0.51035 (0.5014)
	Q4 β (SE)	0.20861 (0.39266)	R4 β (SE)	-0.10884 (0.45901)
Nepal				
	Intercept β (SE)	0.60827 (0.13866) ‡	Intercept β (SE)	0.41107 (0.08195) ‡
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	-0.30927 (0.1935)	R2 β (SE)	-0.08995 (0.20569)
	Q3 β (SE)	-0.28595 (0.20214)	R3 β (SE)	ND
	Q4 β (SE)	-0.29735 (0.18514)	R4 β (SE)	-0.10801 (0.18465)
Senegal				
	Intercept β (SE)	0.09308 (0.13972)	Intercept β (SE)	0.09308 (0.13939)
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	0.32670 (0.24770)	R2 β (SE)	ND
	Q3 β (SE)	0.58337 (0.23691) †	R3 β (SE)	0.46359 (0.19713) †
	Q4 β (SE)	-0.05308 (0.2477)	R4 β (SE)	-0.05308 (0.24711)
Tanzania				

Intercept β (SE)	0.57313 (0.14036) ‡	Intercept β (SE)	0.57313 (0.14786) ‡
Q1 β (SE)	Ref	R1 β (SE)	Ref
Q2 β (SE)	0.23783 (0.17626)	R2 β (SE)	0.22976 (0.22732)
Q3 β (SE)	-0.22383 (0.18377)	R3 β (SE)	0.25603 (0.27662)
Q4 β (SE)	0.23898 (0.20201)	R4 β (SE)	0.01739 (0.17122)

*p < 0.1, †p < 0.05, ‡p < 0.01, ND=No Data

Appendix References

1 United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2017 Revision. United Nations 2017. https://population.un.org/wpp/

2 National Institute of Population Research and Training, Associates for Community and Population Research, ICF International. Bangladesh health facility survey 2014 final report. Dhaka, Bangladesh: : NIPORT, ACPR, and ICF International 2016. https://dhsprogram.com/pubs/pdf/SPA23/SPA23.pdf (accessed 14 Feb 2018).

3 Ecole de Santé Publique de Kinshasa, ICF. République Démocratique du Congo Évaluation des Prestations des Services de soins de Santé (EPSS) 2017-2018. Kinshasa, Democratic Republic of the Congo: : ESPK and ICF 2019. https://dhsprogram.com/pubs/pdf/SPA30/SPA30.pdf (accessed 1 Jul 2019).

4 Ethiopian Public Health Institute, Federal Ministry of Health, ICF International. Ethiopia service provision assessment plus (ESPA+) survey 2014. Addis Ababa, Ethiopia: : EPHI, FMOH, and ICF International 2014. https://www.ephi.gov.et/images/pictures/FINAL%20draft%20SPA+%20%20REPORT%20survey%20tools%20adjusted%20-%20Dec%2024%20%202015.pdf (accessed 14 Feb 2018).

5 Institut Haïtien de l'Enfance, ICF International. Haiti Évaluation de la Prestation des Services de Soins de Santé 2013. Rockville, Maryland, USA: : IHE and ICF International 2014. https://dhsprogram.com/pubs/pdf/SPA19/SPA19.pdf (accessed 14 Feb 2018).

6 Ministry of Health, ICF International. Malawi service provision assessment 2013-14. Lilongwe, Malawi: : MoH and ICF International 2014. https://dhsprogram.com/pubs/pdf/SPA20/SPA20[Oct-7-2015].pdf (accessed 14 Feb 2018).

7 Ministry of Health, New ERA, Nepal Health Sector Support Program, *et al.* Nepal health facility survey 2015 final report. Kathmandu, Nepal: : Ministry of Health, Nepal 2017. https://dhsprogram.com/pubs/pdf/SPA24/SPA24.pdf (accessed 14 Feb 2018).

8 Agence Nationale de la Statistique et de la Démographie, ICF. Sénégal : Enquête Continue sur la Prestation des Services de Soins de Santé (ECPSS) 2017. Dakar, Sénégal: : ANSD and ICF 2018. https://dhsprogram.com/pubs/pdf/SPA27/SPA27.pdf (accessed 1 Jul 2019).

9 Ministry of Health and Social Welfare [Tanzania Mainland], Ministry of Health [Zanzibar], National Bureau of Statistics, *et al.* Tanzania Service Provision Assessment Survey (TSPA) 2014-15. Dar es Salaam, Tanzania: : MoHSW, MoH, NBS, OCGS, and ICF International https://dhsprogram.com/pubs/pdf/SPA22/SPA22.pdf (accessed 14 Feb 2018).

10 Robles Aguilar G, Sumner A. Who Are the World's Poor? A New Profile of Global Multidimensional Poverty. Working Paper 499. Washington, DC: : Center for Global Development 2019. https://www.cgdev.org/publication/who-are-worlds-poor-new-profile-global-multidimensional-poverty (accessed 23 Jan 2019).

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract ***"Cross-sectional" in title***
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found ***Summary provided in abstract***
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported ***Included in introduction***
Objectives	3	State specific objectives, including any prespecified hypotheses ***Objectives stated at end of introduction***
Methods		
Study design	4	Present key elements of study design early in the paper ***Included in methods***
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection ***Setting, locations, dates of surveys, and information on the availability of surveys included in methods***
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants ***Description of surveys included in analysis is in second paragraph of methods***
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable ***Availability defined, sets of medications and equipment defined, extreme poverty operationalized in data analysis section of methods***
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group ***Descriptions of surveys included, availability defined in methods***
Bias	9	Describe any efforts to address potential sources of bias ***Strategies to handle limitations of data included in data analysis section of methods***
Study size	10	Explain how the study size was arrived at ***Data from previously collected publicly available surveys***
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why ***Included in definitions and descriptions of sets of medications and equipment in methods***
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding ***Statistical methods described in data analysis section of methods***
		(*b*) Describe any methods used to examine subgroups and interactions ***Analysis by country/in specific facility types described in methods***
		(*c*) Explain how missing data were addressed ***Missingness described in data analysis section of methods***
		(*d*) If applicable, describe analytical methods taking account of sampling strategy ***Described in methods and referenced to original survey sources***

		(*e*) Describe any sensitivity analyses ***Sensitivity analysis of possible association between availability of medications and equipment and poverty described in methods with reference to appendix for further detail***
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed ***Reported number of facilities in first paragraph of results, full detail in Appendix Table 1***
		(b) Give reasons for non-participation at each stage ***Explanation of sampling given in methods section***
		(c) Consider use of a flow diagram ***We did not consider a flow diagram to be necessary***
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders ***There are not individual participants. Table 1 describes equipment and medications. Appendix Table 1 describes details on country surveys.***
		(b) Indicate number of participants with missing data for each variable of interest ***Missingness of particular variables described in methods section and in Appendix Table 2. Variables with high missingness noted in Tables 2-4 and excluded from reporting.***
Outcome data	15*	Report numbers of outcome events or summary measures ***Proportions of facilities with availability of different medications and equipment reported in tables, along with the number of facilities surveyed***
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included ***Estimates given with 95% confidence interval for samples, no confidence intervals included for country surveys that were intended to include a census of public first-referral hospitals.***
		(*b*) Report category boundaries when continuous variables were categorized ***Continuous variables reported as continuous in main text. Sensitivity analysis in appendix reports categories of extreme poverty prevalence.***
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period ***Not applicable***
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses ***Results from multiple regression specifications described briefly at end of results section and presented in full detail in appendix***
Discussion		
Key results	18	Summarise key results with reference to study objectives ***First paragraph of discussion section summarizes results with reference to objectives***
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias ***Limitations paragraph in discussion section lists and contextualizes limitations.***

Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence ***Study is interpreted with reference to evidence form other studies in discussion and interpretation is summarized at the end of the discussion section.***
Generalisability	21	Discuss the generalisability (external validity) of the study results ***We discuss generalizability across countries as well as across disease types***
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based ***Funding and role of funders is reported***

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Availability of Equipment and Medications for Non-Communicable Diseases and Injuries at Public First-Referral Level Hospitals: A Cross-sectional Analysis of Service Provision Assessments in Eight Low-Income Countries

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-038842.R1
Article Type:	Original research
Date Submitted by the Author:	17-Jun-2020
Complete List of Authors:	Gupta, Neil; Harvard Medical School Department of Global Health and Social Medicine, Program in Global Noncommunicable Diseases and Social Change; Brigham and Women's Hospital, Division of Global Health Equity Coates, Matthew; Harvard Medical School Department of Global Health and Social Medicine, Program in Global Noncommunicable Diseases and Social Change; Brigham and Women's Hospital, Division of Global Health Equity Bekele, Abebe; Ethiopian Public Health Institute, Health System and Reproductive Health Research Directorate Dupuy, Roodney; Le Ministère de la Santé Publique et de la Population Fénelon, Darius Leopold; Zanmi Lasante Gage, Anna; Harvard T.H. Chan School of Public Health, Department of Global Health and Population Getachew, Theodros ; Ethiopian Public Health Institute, Health System and Reproductive Health Research Directorate; University of Gondar College of Medicine and Health Sciences, College of Medicine and Health Science, Institute of Public Health Karmacharya, Biraj; Kathmandu University School of Medical Sciences, Department of Community Medicine Kwan, G.; Harvard Medical School Department of Global Health and Social Medicine, Program in Noncommunicable Diseases and Social Change; Boston University School of Medicine, Section of Cardiovascular Medicine Lulebo, Aimée ; University of Kinshasa, Kinshasa School of Public Health Masiye, Jones; Malawi Ministry of Health Mayige, Mary; National Institute for Medical Research Ndour Mbaye, Maïmouna; Cheikh Anta Diop University, Department of Internal Medicine, University Hospital Center of Dakar Mridha, Malay Kanti; BRAC University, Center for Non-communicable Diseases and Nutrition, BRAC James P Grant School of Public Health Park, Paul; Harvard Medical School Department of Global Health and Social Medicine, Program in Noncommunicable Diseases and Social Change; Brigham and Women's Hospital, Division of Global Health Equity Dagnaw, Wubaye; Partners In Health; Ethiopia Ministry of Health Wroe, Emily; Harvard Medical School Department of Global Health and Social Medicine, Program in Global Noncommunicable Diseases and Social Change; Brigham and Women's Hospital, Division of Global Health

	Equity Bukhman, Gene; Harvard Medical School Department of Global Health and Social Medicine, Program in Global Noncommunicable Diseases and Social Change; Brigham and Women's Hospital, Division of Global Health Equity
Primary Subject Heading:	Global health
Secondary Subject Heading:	Global health, Health services research
Keywords:	CARDIOLOGY, DIABETES & ENDOCRINOLOGY, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, TROPICAL MEDICINE, Asthma < THORACIC MEDICINE, SURGERY

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Availability of Equipment and Medications for Non-Communicable Diseases and Injuries at Public First-Referral Level Hospitals: A Cross-sectional Analysis of Service Provision Assessments in Eight Low-Income Countries

Authors: Neil Gupta[1,2,3], Matthew M Coates[1], Abebe Bekele[4], Roodney Dupuy[5], Darius Leopold Fénelon[6], Anna D Gage[7], Theodros Getachew[4,8], Biraj M Karmacharya[9], Gene F Kwan[1,3,10], Aimée Lulebo[11], Jones K Masiye[12], Mary Mayige[13], Maïmouna Ndour Mbaye[14], Malay K Mridha[15], Paul H Park[1,2,3], Wubaye Walelgne Dagnaw[3,16], Emily B Wroe[1,2,3], Gene Bukhman[1,2,3, 17]

Affiliations:

1. Department of Global Health and Social Medicine, Program in Global Noncommunicable Diseases and Social Change, Harvard Medical School, Boston, USA;
2. Division of Global Health Equity, Brigham & Women's Hospital, Boston, USA;
3. Partners In Health, Boston, USA
4. Health System and Reproductive Health Research Directorate, Ethiopian Public Health Institute, Addis Ababa, Ethiopia;
5. Le Ministère de la Santé Publique et de la Population, Port-au-Prince, Haiti
6. Zanmi Lasante, Haiti
7. Department of Global Health and Population, Harvard T. H. Chan School of Public Health, Boston, USA
8. College of Medicine and Health Science, Institute of Public Health, University of Gondar, Gondar, Ethiopia
9. Department of Community Medicine, Kathmandu University School of Medical Sciences, Dhulikhel, Nepal
10. Section of Cardiovascular Medicine, Boston University School of Medicine, Boston, USA
11. School of Public Health, Kinshasa, The Democratic Republic of the Congo
12. Malawi Ministry of Health, Lilongwe, Malawi
13. National Institute for Medical Research, Dar Es Salaam, Tanzania
14. Department of Internal Medicine, University Hospital Center of Dakar, Cheikh Anta Diop University, Dakar, Senegal
15. Center for Non-communicable Diseases and Nutrition, BRAC James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh
16. Ministry of Health, Federal Democratic Republic of Ethiopia, Addis Ababa, Ethiopia
17. Division of Cardiovascular Medicine, Brigham & Women's Hospital, Boston, USA

Corresponding author: Gene Bukhman, gene_bukhman@hms.harvard.edu, 641 Huntington Avenue Boston, Massachusetts 02115, +1-617-432-6052
Word count: 4203

Abstract

Context and Objectives

Non-communicable diseases and injuries (NCDIs) comprise a large share of mortality and morbidity in low-income countries (LICs), many of which occur earlier in life and with greater severity than in higher income settings. Our objective was to assess availability of essential equipment and medications required for a broad range of acute and chronic NCDI conditions.

Design

Secondary analysis of existing cross-sectional survey data

Setting

We utilized data from Service Provision Assessment surveys in Bangladesh, the Democratic Republic of the Congo, Ethiopia, Haiti, Malawi, Nepal, Senegal, and Tanzania, focusing on public first-referral level hospitals in each country.

Outcome measures

We defined sets of equipment and medications required for diagnosis and management of four acute and nine chronic NCDI conditions and determined availability of these items at the health facilities.

Results

Overall, 797 hospitals were included. Medication and equipment availability was highest for acute epilepsy (country estimates ranging from 40 to 95%) and stage 1-2 hypertension (28-83%). Availability was low for type 1 diabetes (1-70%), type 2 diabetes (3-57%), asthma (0-7%), and acute presentations of diabetes (0-26%) and asthma (0-4%). Few hospitals had equipment or medications for heart failure (0-32%), rheumatic heart disease (0-23%), hypertensive emergencies (0-64%), or acute minor surgical conditions (0-5%). Data for chronic pain was limited to only two countries. Availability of essential medications and equipment was lower than previous facility-reported service availability.

Conclusions

Our findings demonstrate low availability of essential equipment and medications for diverse NCDIs at first-referral level hospitals in eight LICs. There is a need for decentralization and integration of NCDI services in existing care platforms and improved assessment and monitoring to fully achieve universal health coverage.

Strengths and limitations of this study

- To our knowledge, this is the first analysis with cross-country comparisons of readiness at first-referral level hospitals for acute and chronic presentations of a broader range of non-communicable diseases and injuries in low-income countries using practical and well-defined clinical criteria.
- Valid cross-country analysis was possible by comparing facilities at analogous levels of the health system and using Service Provision Assessment data, which is largely standardized across countries.
- The Service Provision Assessment surveys lack longitudinal data, and our analysis does not include information about supply chains, limiting the nature of the description about the availability of medications and equipment.
- While we analyzed data from eight countries representing a variety of low-income countries geographically, there are many more countries excluded from our analysis.

Introduction

Non-communicable diseases (NCDs) and injuries (NCDIs) are major drivers of the disease burden in low-income countries (LICs), accounting for 41% of mortality and morbidity in terms of disability-adjusted life years (DALYs) in 2017.[1] In many LICs, the risk factors, epidemiology, and disease conditions that comprise the burden of NCDIs differs from that seen in higher income countries.[2] In these countries, harmful environments, infectious diseases, and poor access to timely and high-quality health services are important factors contributing to the burden of NCDs.[3,4]

Health-sector interventions to address this burden have been increasingly recognized as both cost-effective and equitable, particularly for severe NCDIs affecting individuals early in life.[2,5] In many LICs, availability of services to diagnose and manage NCDs is low and most often found primarily in urban higher-level hospitals.[4] However, several NCDI interventions may be optimally delivered at first-referral level hospitals, which have been recognized as an essential component of the primary health care system.[5] These first-referral hospitals, called district hospitals in some health systems, provide an opportunity to decentralize care, as they are more accessible to patients than tertiary referral hospitals and more capable of providing advanced services than health centers.[6,7] Populations in rural areas, which tend to have higher rates of poverty in LICs,[8] often face challenges accessing health care at distant facilities.[9] Although one study has shown low readiness of health facilities in five LICs to deliver general services for cardiovascular disease, diabetes, and chronic respiratory diseases,[4] there has been limited multi-country assessment of hospital capacity to deliver a broader range of priority NCDI interventions. Some facility surveys assessing readiness and quality of care for other types of care, such as for maternal health, have found lower quality in facilities located in areas with higher rates of poverty.[10]

In this study, we evaluated the availability of equipment and medications for management and diagnosis of the acute and chronic presentations of a broad range of NCDIs at first-referral level hospitals in eight LICs: Bangladesh, the Democratic Republic of the Congo (DRC), Ethiopia, Haiti, Malawi, Nepal, Senegal, and Tanzania. We selected specific NCDIs with potentially severe presentations early in life, including asthma, hypertensive emergencies, heart failure, rheumatic heart disease, type 1 and 2 diabetes, epilepsy, injuries and minor surgical conditions, and chronic pain. Given previous findings linking poverty and healthcare quality,

we examined whether there were associations between subnational prevalence of extreme poverty and availability of equipment and medications. To the best of our knowledge, the countries we included in this study are the only LICs with comparable, openly available, nationally representative data on NCDI service provision recently collected via a standardized survey.

Methods

Study Setting and Data Sources

We utilized publicly available data from all Service Provision Assessment (SPA) surveys conducted in LICs through 2018. The SPA surveys are nationally-representative health facility assessments administered as part of the Demographic and Health Survey (DHS) program.[11] These surveys were designed to assess human resources, infrastructure, equipment and medications available for maternal and child health (MCH) and priority infectious diseases.[11] In 2012, the SPA questionnaires were updated to include indicators for some NCDIs, including infrastructure, human resources, medications, equipment, and guidelines. Survey collectors indicate medications and equipment as available if they directly observe these items on the day of the survey.

Since the initial inclusion of questions on NCDs, SPA surveys had been completed as of 2018 in eight LICs representing a broad range of geography, population size, economic productivity, health care expenditure, and health system capacity: Bangladesh (2014), the DRC (2017-18), Ethiopia (2014), Haiti (2013), Malawi (2013-14), Nepal (2015), Senegal (2016-17), and Tanzania (2014-15) (Appendix Table 1).[12] Bangladesh subsequently graduated to lower-middle income status in 2015, and Senegal was moved from a lower-middle-income country to a low-income country in 2017 and back to a lower-middle-income country in 2020. These countries, excluding Senegal and Bangladesh, together represent 19% of countries classified as LICs by the World Bank for the 2020 fiscal year and 44% of the global population living in LICs.[13,14] The surveys in Haiti and Malawi were facility censuses, intended to capture all health facilities in the country. In Nepal, all public facilities were in the sampling frame and almost all public hospitals were surveyed. All hospitals in Ethiopia were included in the survey collection, along with a representative sample of private clinics and health centers. In Tanzania, all types of facilities were in the sampling frame, and 99% of hospitals were selected for the sample. In the DRC, the survey was done using a stratified random sample to obtain results by province and type of health facility. In Bangladesh, the surveys were conducted on a stratified random

sample of facilities to obtain representative estimates by seven administrative divisions and by facility types (including a census of public district hospitals but a sample of public upazila health complexes). The combined 2016 and 2017 surveys in Senegal essentially includes a census of hospitals. Full details on the data from each country can be found in online reports, along with survey instruments.[12] Data from these surveys were obtained from the DHS program (www.dhsprogram.com).

We build on methods previously developed to assess the quality of primary health care using similar datasets.[15,16] The datasets were cleaned and standardized across the countries, categorizing facilities as hospitals, health centers and clinics, or other facilities such as dispensaries. Facility weights used in analysis accounted for survey design and nonresponse to ensure representativeness, as oversampling is often done for certain facility types in these surveys. Our assessment focused on public first-referral hospitals. We regarded first-referral level hospitals as the first point of care for patients requiring referral from a primary health center level, and the names for these facility types varied across countries. We limited our analysis to public-sector facilities to optimize evaluation of health system investment and capacities provided from government sources for the poorest segment of the population, though data is not available within SPA surveys to specify payment source and mechanism for each commodity or service provided. In Nepal, we classified public district hospitals as first-referral level hospitals. In Bangladesh, we classified upazila health complexes as first-referral level hospitals because they are described as hospitals with in-patient beds and surgical care, occupy a lower level than district hospitals in Bangladesh, and have population catchment areas similar to district hospitals in other countries (1 facility per 375,000 population, compared to a range across other countries of 1 facility per ~175,000-560,000). In Malawi and Tanzania, we combined public district hospitals with public rural/community hospitals (Malawi) and district designated hospitals (Tanzania) as first-referral level hospitals. In Haiti, we used the community referral hospital classification. In Senegal, we reported on all public hospitals because more specific categories were not available from the SPA data. In the DRC, we used public hospitals below the provincial/tertiary level, though we could not differentiate between additional categories from the available data. In Ethiopia, we used both primary hospitals and general hospitals given the relatively recent introduction of primary hospitals and similarities in service delivery standards. Additional details can be found in Appendix Table

1. The study protocol was reviewed and determined non-human subject research by the Institutional Review Board of the Harvard Faculty of Medicine.

Data Analysis

We analyzed the availability of essential equipment and medications required for diagnosis and treatment of nine chronic disease states and four acute presentations of eleven NCDI conditions (Table 1). We defined the minimum set of essential equipment and medications for the diagnosis and treatment of each condition using existing guidelines and iterative expert review from a group of public health practitioners, researchers, and clinicians familiar with the local contexts. Acute conditions are those that require urgent procedures or hospitalization, whereas chronic conditions were those requiring longitudinal follow-up for ongoing monitoring and disease management. The availability of the full essential set of functioning equipment and unexpired medications was determined for each facility. We considered equipment available if it was present in general outpatient, NCD, or minor surgical areas. Medications were considered available if they were observed present and unexpired. In most cases, the data necessary to create these sets were available. In cases in which a survey question about one of the components of the equipment and medication set for a condition was not answered but the rest of the components were present at the facility, the facility received an "unknown" classification for that set. If any one of the components was unavailable, then the essential set was classified as unavailable. Surveys in some countries did not contain questions about all of the relevant medications and equipment. In these cases, as well as in countries with >10% missing data for a particular variable, the country was excluded from analysis (see Appendix Table 2 for list of missing variables). Missing variables and "unknown" classifications for a set of equipment and medications were rare, resulting most frequently from surveys in particular countries excluding certain pain medications or surgical equipment. A total of 21 out of 797 public first-referral hospitals (less than 3%), 20 of these in Bangladesh, did not provide NCD services according to the survey. If these particular facilities were missing data for particular medications or equipment, we assumed the medications or equipment were unavailable. The availability of the essential sets of equipment and medications and their component items were tabulated by geographic units (both by country and by subnational units within countries). We also compared the proportion of facilities that reported diagnosing and managing chronic respiratory diseases, cardiovascular diseases, and diabetes with the availability of essential equipment and medications for asthma, diabetes, hypertension, heart

failure, and rheumatic heart disease at those same facilities. We reported 95% confidence intervals (CI) for estimates using standard survey tabulation methods for countries that surveyed a sample of public first-referral hospitals (Bangladesh and the DRC) but not for countries where surveys were intended as a facility census. The surveys from Bangladesh and the DRC sampled a relatively large proportion of the total number of hospitals, so we calculated the 95% CI incorporating a correction for finite population size.

Table 1. **Assigned essential equipment and medications for acute presentations of and chronic care for NCDI conditions at first-referral level hospitals**

Disease Area	**Essential Equipment and Medications**	
	Acute Care	Chronic Care
Asthma	Pulse oximeter, peak flow meter, oxygen, x-ray, salbutamol inhaler, prednisolone, hydrocortisone injection, nebulizer	Stethoscope, salbutamol inhaler, beclomethasone inhaler, prednisolone
Hypertension (Stage 1 or 2)		Blood pressure apparatus, stethoscope, at least two classes of anti-hypertensive medications (calcium channel blocker, ACE inhibitor, thiazide diuretic, or beta blocker)
Hypertension requiring 3 anti-hypertensive classes		Essential equipment and medications for hypertension stage 1 or 2 (above), one additional class of anti-hypertensive medications
Hypertension requiring 4 anti-hypertensive classes		Essential equipment and medications for hypertension stage 1 or 2 (above), two additional class of anti-hypertensive medications
Heart Failure		Adult weighing scale, stethoscope, blood pressure apparatus, ACE inhibitor, beta-blocker, furosemide, ultrasound*
Rheumatic Heart Disease		Essential equipment and medications for heart failure (above), oral penicillin or benzathine penicillin injection, epinephrine injection
Diabetes Type 1	Blood pressure apparatus, serum blood glucose test, renal function testing, intravenous saline, infusion kit for IV fluids, insulin, glucose injection solution	Serum glucose, insulin
Diabetes Type 2		Serum glucose, metformin or glibenclamide
Epilepsy	Diazepam injectable	Diazepam tablet or phenobarbitone or carbamazepine**
Injury / Acute Minor Surgical Conditions	Needle holder, scalpel handle and blades, retractor, surgical scissors, nasogastric tube, tourniquet, oxygen, skin disinfectant, suture, ketamine, lidocaine (5%)	
Pain Care		Oral morphine, injectable morphine or injectable pethidine, one non-opioid analgesic (paracetamol, ibuprofen, aspirin, or diclofenac)

*We did not make a determination about whether the appropriate ultrasound probes were available for heart failure diagnostic purposes, only whether there was any functional ultrasound machine. **Epilepsy chronic care not included in results—availability of tablets not included on survey in most countries.

To examine a potential association between the availability of NCDI medications and equipment with the prevalence of extreme poverty in sub-national regions, we used a modified version of the Multidimensional Poverty Index from the Oxford Poverty and Human Development Initiative (Appendix Tables 3 & 4).[8] We counted the number of the individual components across our disease-related sets of medications and equipment (Table 1) that were available on the day the survey was conducted at each facility, de-duplicating items in multiple sets. We assessed the association between the logit-transformed proportion of the total items available in a public first-referral level hospital and the prevalence of extreme poverty in the subnational unit (district or region) where the hospital was located using linear regression. We conducted regressions separately for each country to account for likely differences in governance and health systems. We used different regression specifications to assess the association between the availability of equipment and medications and the prevalence of extreme poverty. In one model specification, we used the prevalence of extreme poverty as a continuous variable, assuming a linear association. For possible nonlinear association, we additionally used model specifications categorizing extreme poverty prevalence into categorical groups by quartiles and by evenly spaced ranges of prevalence in each country. We also examined the association between the density of public first-referral level hospitals and hospitals per population in subnational areas with the prevalence of extreme poverty using linear regressions, accounting for country differences. Full details for these analyses are described in the appendix.

Data cleaning, formatting, and preparation were conducted using Stata/IC 15.1 (StataCorp, College Station, Texas), and tabulations and regressions were conducted using R version 3.5.1 (the R Foundation for Statistical Computing).

Patient and Public Involvement

This research study was conducted without patient or public involvement in the design, execution, or dissemination of the study.

Results

Overall, of the 9,375 heath facilities across the eight countries which were surveyed, we identified 797 public first-referral level hospitals. Table 2 shows the availability of sets of equipment and medications for condition-specific acute care services, including surgery. The availability at these facilities of the complete set of essential equipment and medications needed for diagnosis and chronic care of specific conditions is shown in Table 3.

***Table 2*. Availability of complete essential equipment and medications for acute presentations of NCDIs at public first-referral level hospitals in eight low-income countries**

	Percent of Facilities with Available Medications and Equipment, % (95% CI)							
	Bangladesh (n=140)	**The Democratic Republic of the Congo† (n=283)**	**Ethiopia (n=117)**	**Haiti (n=25)**	**Malawi (n=43)**	**Nepal (n=76)**	**Senegal‡ (n=37)**	**Tanzania (n=76)**
Acute Asthma	0 (0,3)	1 (1,2)	0	0	0	4	0	0
Functional X-Ray Machine	24 (17,31)	31 (29,33)	64	52	51	86	78	70
Hydrocortisone Injection	47 (39,54)	82 (81,84)	68	52	26	78	67	80
Micronebulizer in NCD or General Outpatient Area	59 (52,67)	6 (5,7)	6	20	21	37	54	4
Oxygen Availability (cylinder or concentrator, plus distribution) in NCD or General Outpatient Area	54 (47,62)	10 (9,11)	14	28	12	12	46	4
Peak Flow Meter in NCD or General Outpatient Area	25 (19,33)	3 (2,4)	8	16	5	30	33	7
Prednisolone	20 (14,27)	50 (47,53)	89	52	77	50	0	76
Pulse Oximeter in NCD or General Outpatient Area	29 (22,36)	11 (9,13)	14	8	21	30	52	11
Salbutamol Inhaler	19 (14,26)	38 (35,41)	82	48	58	91	48	33
Acute Diabetes	0 (0,3)	6 (5,7)	5	4	26	0	0	17
Blood Glucose Test Equipment	27 (21,34)	77 (75,79)	85	40	56	20	9	63
Blood Pressure Apparatus in NCD or General Outpatient Area	99 (93,100)	98 (98,99)	95	96	79	97	87	84
Infusion Kit for IV Fluids in NCD or General Outpatient Area	57 (49,64)	45 (43,48)	34	32	81	38	8	70
Injectable Glucose	11 (7,18)	70 (67,73)	24	40	98	92	91	62
Injectable Saline Solution	72 (64,78)	69 (67,72)	96	52	91	95	82	92
Insulin	1 (0,4)	48 (46,51)	79	12	58	12	51	89
Liver and Kidney Function Diagnostics (Creatinine, Electrolytes)	11 (7,17)	24 (22,26)	47	60	40	38	93	74
Acute Epilepsy	49 (42,57)	81 (78,82)	91	40	95	72	85	91
Diazepam Injection	49	81	91	40	95	72	85	91

	(42,57)	(78,82)						
Injuries / Acute Minor Surgical Conditions *	NA	2 (2,3)	5	0	0	4	2	1
Ketamine in Minor Surgical Area	NA	76 (74,78)	61	20	37	24	3	49
Lidocaine in Minor Surgical Area	NA	80 (77,83)	97	92	95	93	82	99
Nasogastric Tubes in Minor Surgical Area	NA	43 (41,46)	66	40	14	41	23	30
Needle Holder in Minor Surgical Area	NA	98 (97,98)	97	92	100	97	97	95
Oxygen Availability (cylinder or concentrator, plus distribution) in NCD or General Outpatient Area	54 (47,62)	10 (9,11)	14	28	12	12	46	4
Retractor in Minor Surgical Area	NA	85 (84,86)	84	40	44	49	24	41
Scalpel in Minor Surgical Area	NA	86 (83,88)	92	40	74	86	73	78
Skin Disinfectant in Minor Surgical Area	NA	97 (96,97)	99	88	84	95	97	92
Surgical Scissors in Minor Surgical Area	NA	99 (99,99)	97	96	88	95	98	91
Sutures in Minor Surgical Area	NA	85 (83,87)	93	68	93	78	55	92
Tourniquet in Minor Surgical Area	NA	25 (23,27)	54	68	26	67	94	34

NA = No data available or >10% missing data

Numbers reported % (95% confidence interval). Uncertainty not reported for surveys that were intended to include complete census of facilities (all except Bangladesh and the Democratic Republic of the Congo).

†Democratic Republic of the Congo estimates are reported for non-tertiary, non-provincial-level public hospitals

‡Senegal data did not allow for separation of first-referral and higher level hospitals, results reported here for all public hospitals

*Most surgical equipment items are missing data in 5-10% of facilities in Haiti, Malawi, and Senegal. Percentages reported in this table exclude facilities with missing data for a given indicator. Overall percentage of surgical medications and equipment availability unaffected by these missing data, as oxygen unavailable in these missing cases, making overall surgical set unavailable.

Table 3. **Availability of complete essential equipment and medications for chronic care of NCDI conditions at public first-referral level hospitals in eight low-income countries**

	Percent of Facilities with Available Medications and Equipment, % (95% CI)							
	Bangladesh (n=140)	**The Democratic Republic of the Congo† (n=283)**	**Ethiopia (n=117)**	**Haiti (n=25)**	**Malawi (n=43)**	**Nepal (n=76)**	**Senegal‡ (n=37)**	**Tanzania (n=76)**
Asthma	0 (0,3)	1 (1,2)	7	4	5	5	0	0
Beclomethasone Inhaler	5 (2,10)	2 (1,2)	8	8	5	9	3	0
Prednisolone	20 (14,27)	50 (47,53)	89	52	77	50	0	76
Salbutamol Inhaler	19 (14,26)	38 (35,41)	82	48	58	91	48	33
Stethoscope in NCD or General Outpatient Area	100 (98,100)	98 (97,98)	99	96	95	99	83	96
Hypertension (Stage 1 or 2)	31 (24,39)	28 (25,30)	83	76	44	45	38	70
At Least Two of: Calcium Channel Blocker, ACE inhibitor, Thiazide, Atenolol	33 (26,40)	28 (26,30)	89	84	53	46	48	83
Blood Pressure Apparatus in NCD or General Outpatient Area	99 (93,100)	98 (98,99)	95	96	79	97	87	84
Stethoscope in NCD or General Outpatient Area	100 (98,100)	98 (97,98)	99	96	95	99	83	96
Hypertension Requiring 3 Anti-hypertensive Classes	6 (3,12)	9 (8,10)	64	56	26	12	2	51
At Least Three of: Calcium Channel Blocker, ACE inhibitor, Thiazide, Atenolol	8 (5,14)	9 (8,10)	69	60	28	12	2	57
Blood Pressure Apparatus in NCD or General Outpatient Area	99 (93,100)	98 (98,99)	95	96	79	97	87	84
Stethoscope in NCD or General Outpatient Area	100 (98,100)	98 (97,98)	99	96	95	99	83	96
Hypertension Requiring 4 Anti-hypertensive Classes	2 (1,7)	2 (1,3)	34	20	12	0	0	9
All of: Calcium Channel Blocker, ACE inhibitor, Thiazide, Atenolol	3 (1,7)	2 (1,3)	34	20	12	0	0	14
Blood Pressure Apparatus in NCD or General Outpatient Area	99 (93,100)	98 (98,99)	95	96	79	97	87	84
Stethoscope in NCD or General Outpatient Area	100 (98,100)	98 (97,98)	99	96	95	99	83	96
Heart Failure	1 (0,5)	6 (5,7)	26	8	12	0	5	32
Adult Scale in NCD or General Outpatient Area	84 (77,89)	97 (96,97)	71	84	72	95	74	86
Atenolol or other Beta-blocker	55 (47,62)	10 (9,11)	69	56	21	57	5	70
Blood Pressure Apparatus in NCD or General Outpatient Area	99 (93,100)	98 (98,99)	95	96	79	97	87	84
Captopril, Enalapril, or other ACE inhibitor	14 (9,21)	38 (35,40)	80	88	49	0	71	78
Furosemide	22 (16,29)	84 (81,86)	92	64	63	93	86	78
Stethoscope in NCD or General Outpatient Area	100 (98,100)	98 (97,98)	99	96	95	99	83	96
Ultrasound Equipment	5 (2,9)	62 (59,64)	57	52	51	62	8	68
Rheumatic Heart Disease	0 (0,0)	2 (2,3)	19	0	9	NA	0	23

Essential Heart Failure Medications and Equipment	1 (0,5)	6 (5,7)	26	8	12	0	5	32
Benzathine Penicillin	14 (9,21)	53 (50,56)	87	36	100	NA	53	82
Oral Penicillin*	NA	NA	NA	NA	NA	NA	NA	NA
Injectable Epinephrine	2 (1,5)	29 (27,32)	70	8	88	63	56	75
Type 1 Diabetes	1 (0,4)	38 (36,41)	70	8	44	3	5	58
Blood Glucose Test Equipment	27 (21,34)	77 (75,79)	85	40	56	20	9	63
Insulin	1 (0,4)	48 (46,51)	79	12	58	12	51	89
Type 2 Diabetes	9 (5,14)	40 (37,42)	75	32	42	14	3	57
Blood Glucose Test Equipment	27 (21,34)	77 (75,79)	85	40	56	20	9	63
Metformin or Glibenclamide	27 (21,35)	49 (46,51)	86	76	58	61	34	88
Pain Care	NA	NA	NA	NA	58	NA	NA	54
Injectable Morphine or Pethidine	NA	NA	NA	NA	58	NA	NA	54
Oral Pain Medication (Paracetamol, Ibuprofen, Aspirin, or Diclofenac)	100 (97,100)	100 (97,100)	100	100	100	99	NA	100

NA = No data available or >10% missing data

Numbers reported % (95% confidence interval). Uncertainty not reported for surveys that were intended to include complete census of facilities (all except Bangladesh and the Democratic Republic of the Congo).

†Democratic Republic of the Congo estimates are reported for non-tertiary, non-provincial-level public hospitals

‡Senegal data did not allow for separation of first-referral and higher level hospitals, results reported here for all public hospitals

* For oral penicillin, question not asked on most surveys (Tanzania, Senegal, Nepal, Haiti) and high missingness proportion in Bangladesh and Malawi. We therefore do not report proportions here. For creating rheumatic heart disease combined set, it did not affect results, as only 1 facility had missing data for oral penicillin when other necessary components available (heart failure set, epinephrine)

Overall, medication and equipment availability was highest for acute management of epileptic seizures with diazepam (ranging between 40 and 95% in countries), followed by chronic care of stage 1 to 2 hypertension (ranging between 28 and 83%), although this declined with hypertension requiring more classes of medications (ranging between 0 and 34% for 4 classes of medications) (Figure 1). Medication and equipment availability was low both for type 2 diabetes (requiring only oral medications) as well as type 1 diabetes requiring insulin. Availability was particularly low for management of acute presentations of diabetes such as diabetic ketoacidosis requiring intravenous fluids and monitoring of blood chemistries. Availability of essential equipment and medications for both acute and chronic presentations of asthma was extremely low in part due to the absence of beclomethasone inhalers at most facilities. Few hospitals had equipment or medications needed to diagnose and manage heart failure and rheumatic heart disease, which required ultrasound equipment. Essential surgical supplies were missing at most hospitals. Most countries had insufficient data to report on the availability of adequate medications to provide treatment of chronic pain.

Notably, there was much lower observed availability of essential medications or equipment for NCDIs than the self-reported availability of services for these conditions by the facility (Table 4). For chronic respiratory diseases, across six countries (not collected in Bangladesh or Malawi), over 75% of public first-referral hospitals reported diagnosis and management services, though fewer than 7% had the essential medications and equipment available for chronic asthma care and fewer than 4% for care of acute asthma exacerbations. Similarly, at least 66% of public first-referral hospitals in each country reported availability diagnostic and management services for diabetes, with the exceptions of Bangladesh (43%) and Malawi, where diagnosis *or* management was reported in 84% of these hospitals. Compared to this reported service provision, availability of essential medications and equipment were lower for type 1 diabetes (1.3-70.1%), type 2 diabetes (3.3-75.2%), and acute care for diabetic ketoacidosis (0-25.6%). Between 48.8% and 94.3% of the hospitals reported availability of diagnostic and management services for cardiovascular diseases, though availability of essential medications and equipment were lower for hypertension (27.7-82.9%), heart failure (0-31.6%), and rheumatic heart disease (0-22.9%).

Table 4. **Observed equipment and medication availability for selected NCDIs compared to self-reported service availability at public first-referral hospitals**

		Percent of Facilities with Available Medications and Equipment, % (95% CI)							
		Bangladesh (n=140)	**The Democratic Republic of the Congo† (n=283)**	**Ethiopia (n=117)**	**Haiti (n=25)**	**Malawi‡ (n=43)**	**Nepal (n=76)**	**Senegal* (n=37)**	**Tanzania (n=76)**
Self-reported Diagnosis and Management	**Chronic Respiratory Disease**	**NA**	**87 (85,89)**	**95**	**96**	**93‡**	**96**	**92**	**75**
Observed Medication and Equipment Availability	Asthma	0 (0,3)	1 (1,2)	7	4	5	5	0	0
	Asthma Acute Care	0 (0,3)	1 (1,2)	0	0	0	4	0	0
Self-reported Diagnosis and Management	**Diabetes**	**43 (36,51)**	**89 (87,90)**	**83**	**92**	**84‡**	**84**	**86**	**75**
Observed Medication and Equipment Availability	Diabetes Type 1	1 (0,5)	38 (36,41)	70	8	44	3	5	58
	Diabetes Type 2	9 (5,15)	40 (37,42)	75	32	42	14	3	57
	Diabetes Acute Care	0 (0,3)	6 (5,7)	5	4	26	0	0	17
Self-reported Diagnosis and Management	**Cardiovascular Disease**	**49 (41,56)**	**94 (93,95)**	**93**	**92**	**98‡**	**91**	**92**	**73**
Observed Medication and Equipment Availability	Hypertension Stage 1 or 2	31 (24,39)	28 (25,30)	83	76	44	45	38	70
	Heart failure	1 (0,5)	6 (5,7)	26	8	12	0	5	32
	Rheumatic Heart Disease	0 (0,3)	2 (2,3)	19	0	9	NA	0	23

NA = No data available

Numbers reported % (95% confidence interval). Uncertainty not reported for surveys that were intended to include complete census of facilities (all except Bangladesh and the Democratic Republic of the Congo).

†Democratic Republic of the Congo estimates are reported for non-tertiary, non-provincial-level public hospitals

‡Malawi only reported *Diagnosis or management* instead of *Diagnosis and management* for self-reported measures

*Senegal data did not allow for separation of first-referral and higher level hospitals, results reported here for all hospitals

There was inconsistency in associations between availability of medications and equipment in public first-referral hospitals and prevalence of extreme poverty in corresponding sub-national units, both across countries and between regression approaches (Appendix Figure 1 and Appendix Tables 5 and 6). For example, there was a negative association in Bangladesh and the DRC, while there was a positive association in Ethiopia and Haiti. These findings also varied across model specifications. The method for grouping hospitals based on prevalence of extreme poverty in sub-national areas affected the estimates of association. Full regression results are shown in appendix Tables 5 and 6. The density of public first-referral level hospitals per population did not vary by poverty prevalence, though there was evidence that the density of hospitals overall as lower in poorer sub-national areas.

Discussion

Our findings demonstrate that availability of essential equipment and medications for acute and chronic services for NCDI conditions across LICs remains extremely low at public first-referral level hospitals. Furthermore, the availability of essential equipment and medications for NCDI services is much lower than facility-reported management and diagnosis of chronic respiratory diseases, diabetes, and cardiovascular diseases. Although we found some evidence of associations, both positive and negative, between availability of essential equipment and medications at a public first-referral level hospital and the prevalence of extreme poverty in the corresponding sub-national area, results were inconsistent.

Facilities included in this study were more equipped to provide services for the treatment of stage 1 and 2 hypertension as compared to other more complex conditions. Previous facility assessments have demonstrated similar levels of medication availability for HTN treatment in low-income countries,[17,18] and significantly lower availability as compared to high-income countries.[19] The low availability of essential medications and equipment likely contributes to low overall coverage of services for hypertension. The Lancet Commission on Hypertension reported that for countries in sub-Saharan Africa (SSA) with household level surveys, over half of hypertensive adults had not been diagnosed, and treatment coverage was low, ranging from 7-61%.[20] Effective coverage was even lower, ranging from 1-31%.[20]

Systematic reviews of heart failure in LICs have identified a high burden of non-ischemic heart failure and high utilization of diuretic therapy, though have not assessed systems readiness or medication

availability.[21,22] One study utilizing a health facility assessment of hospitals in Kenya and Uganda reported higher availability of beta-blockers (98% and 92%, respectively) and furosemide (98% and 94%, respectively), but similar availability of ultrasound equipment and ACE-inhibitors, as compared to that found in our study.[23] The availability of ultrasound has remained a limiting factor for the diagnosis and monitoring of heart failure and has been a focus of health systems diagnostic improvements and training in LICs.[23] Availability of equipment and medications was similarly low for outpatient management of RHD, a common cause of heart failure in LICs. Availability of benzathine penicillin for primary and secondary RHD prophylaxis was highly limited across most countries. Although no detailed health facility reports exist for the availability of benzathine penicillin at primary health facilities across LICs, there have been global concerns for the availability and quality of this essential medication.[24]

Our findings of availability of medications and equipment for diabetes services are consistent with previous reports of low availability of services and low coverage of diabetes services in low-income countries. In a group of 12 countries in SSA, only 22% of eligible individuals had received blood glucose measurement.[25] Of those meeting biochemical criteria for diabetes, only 36% had previously received blood glucose measurement, 27% had been previously diagnosed, 25% were taking oral diabetes therapy, and 11% were taking insulin.[25]

The availability of medications or services for asthma and other chronic respiratory diseases has not been well studied in low-income settings. Inhaled beta agonists, inhaled corticosteroids, and systemic corticosteroids have more recently been included on lists for essential medicines in low-income countries, and price fluctuations have created a wide range of affordability for these medications.[26]

Care for chronic epilepsy has traditionally been lacking in resource-poor settings.[27] Despite the availability of benzodiazepines for acute management of seizures at the inpatient level, the management of chronic epilepsy and seizure prophylaxis is highly lacking. The SPA survey collects information on a limited number of medications that are used for daily prophylaxis of seizures in epileptic disorders and most countries did not include this in their surveys (only Nepal collected data on carbamazepine and phenobarbital). Others have reported the lack of coverage data, and the highly vulnerable characteristics of patients with epilepsy contribute to poor access to care, utilization of available services, and poor overall coverage, resulting in high

morbidity and mortality from epilepsy.[28] The availability of second-line medications or intensive care for refractory seizures was not available.

The extremely low availability of surgical equipment and medications for care of injuries and acute minor surgical conditions is consistent with previous reports.[29] Recent modeling estimates have suggested that coverage of adequate surgical services in SSA and South Asia is less than 5% with sporadic and variable availability of individual tracer items.[30] The ability of surgical interventions to offer one-time curative treatment leads to the high cost-effectiveness and financial risk protection offered by surgical interventions in low-income health systems.[31] Additionally, there is limited data collected in the SPA survey regarding the availability of palliative care services or essential medications, and the data collected was limited only to medications for pain, such as analgesics and opiates. The availability of injectable morphine was collected in only three of the eight countries and availability of oral morphine in only two of the eight countries. This is consistent with the dearth of development in palliative care policies and implementation in low-income countries, particularly in SSA and a dramatic gap in the availability of morphine and other essential medications for palliative care.[32,33]

Countries did vary in their level of availability of essential equipment and medications for the conditions analyzed. Senegal displayed consistently lower rates of availability of equipment and medications than the other countries. In contrast, Ethiopia and Tanzania displayed considerably higher rates than other countries across many conditions, including most notably for hypertension, diabetes care and heart failure. In these two countries there was a relatively early recognition and coordinated approach to NCDs, including strategic and costed operational planning, strong civil society engagement and leadership, progressive outreach from well-established tertiary centers, and a strong and well-organized primary care network.[34,35]

This study has several limitations. First, the essential equipment and medications for NCDI services defined here does not include presence of well-trained and supervised human resources, a cornerstone for healthcare delivery and one that has been well-established to be lacking for NCDs in SSA.[36] The availability of essential equipment and medications presented in this analysis may therefore overestimate the overall service availability for the corresponding condition. Second, certain equipment and medications may have been observed within the health facility, but these items may not necessarily be accessible to the unit providing

NCDI services within the facility (i.e., ultrasound may be reserved for obstetrics) or affordable by the patients. We minimized this possibility by including equipment and medications from general outpatient, NCD, and minor surgical areas. Additionally, medication availability may fluctuate; however, the date of data collection is randomly assigned and should not bias our findings. Third, the components of these sets of equipment and medications may not be comprehensive of all items needed for care associated with each disease condition, but rather represent a core number of elements measured within the available survey tools. Fourth, availability of supplies and equipment is not always associated with quality care.[37] While there are no data available capturing nationally representative observations of the quality of NCDI services, previous studies in the field of maternal and child health suggest that poor quality care can exist even in the presence of necessary supplies.[38] Fifth, there is some incomplete data for specific disease conditions in certain countries reflecting adaptation of the SPA questionnaire by country teams. Sixth, the year of survey data collection varied amongst countries, which may limit direct comparison, and the results may underestimate current levels of availability if substantial improvements have been made following the data collection period, particularly in countries with older surveys. Finally, the level of geographical specificity for extreme poverty prevalence estimates limited the design of the analysis examining associations between poverty and the availability of medications and equipment. Further study is warranted, both with more specific data about populations in de facto catchment areas of facilities and process information about how factors like supply chains and planning affects variation in availability across facilities.

Our findings have several implications to improve service availability of NCDIs in LICs. There is a need to prioritize decentralization of a broad set of cost-effective and equitable interventions at first-referral level hospitals to increase care availability. Such interventions may include those typically confined to referral and university teaching hospitals and densely populated urban areas, such as chronic care delivery for severe NCDIs including heart failure, type 1 diabetes, advanced asthma, and palliative care. Our finding that the density of hospitals per population is lower in poorer subnational areas, while the distribution of first-referral hospitals is more equitable, suggests that decentralization of services can create more equitable access. Collaborations to develop such service packages have recently been launched.[39] Several studies have reported promising outcomes for task-shifting and task sharing of essential NCD services to support decentralization and increase availability of such services.[40–42] Integration of NCD services with existing

HIV and MCH services has been suggested as a cost-effective and important step towards increasing the availability of services in a universal health coverage (UHC) package, particularly at the primary care level.[43] Coordination of governance and policy making for NCDI health sector interventions would also provide opportunities for integration of staff, training, guidelines, and supply chains required for adequate service delivery.[44] Health financing for integrated platforms of NCDI service delivery within a UHC framework will be essential to improve basic availability of services. A high priority package for essential interventions for NCDIs within UHC has been proposed, and may provide reasonable cost estimates required to increase coverage of health sector services for NCDIs, including cross-cutting approaches to mental health, surgery, palliative care, and rehabilitation.[5]

The strengthening of health facility monitoring, and extension of core NCDI indicators is highly needed.[45] Although some readiness indices exist within standardized surveys, such as SPA and the Service Availability and Readiness Assessment (World Health Organization), these are typically limited to outpatient management of hypertension, type 2 diabetes, and asthma. These surveys do not measure readiness for acute complications or inpatient needs, rely in part on reported (rather than observed) measures, and do not identify minimum requirements for service delivery. An appropriate monitoring framework for NCDIs will need to include a greater number of tracer items that reflect current clinical guidelines, other NCDI conditions currently not represented in existing monitoring frameworks but represent a large burden of disease (i.e., cancer, epilepsy, mental health, renal failure, liver cirrhosis, palliative care surgical services), and domains such as organization, management, access, availability, and quality of effective services.[46] Additional examination of costing data, procurement processes, and the supply chain could identify the drivers of stockouts.

Our findings demonstrate variable but overall low availability of the minimum required equipment and medications to provide adequate diagnostic and therapeutic interventions for nine chronic conditions and four acute presentations of chronic conditions at first-referral level hospitals in eight LICs in three different regions. This observed availability of medications and equipment is substantially lower than self-reported diagnosis and management of chronic diseases by facilities in these countries. The provision of cost-effective and equitable health sector interventions for the diagnosis and management of both acute and chronic

presentations of NCDIs are highly needed at first-referral level hospitals in LICs. The strengthening of these services through the public sector can help keep patients from facing high costs for medicines and procedures. There is a need for progressive decentralization of services for these conditions to first-referral level facilities, integration of such services in existing platforms of care, and improved assessment and monitoring of delivery of services in LICs to fully achieve targets established for UHC.

Contributors

GB initiated the study. NG, MMC, and GB designed the analysis. NG conducted the literature search. ADG and MMC conducted data cleaning. MMC conducted data analysis. NG, MMC, and GB drafted the manuscript. All authors (GB, NG, MMC, AB, RD, DLF, ADG, TG, BMK, GFK, AL, JKM, MM, MNM, MKM, PHP, WWD, and EBW) contributed to data interpretation and critical evaluation and revision of the study manuscript.

Acknowledgements

The authors would like to thank Gisela Robles Aguilar for estimation of subnational poverty prevalence, as well as Mamka Anyona for assistance with initial data analysis and Chris Noble for support with manuscript preparation. Gene F. Kwan was supported in part from the National Institutes of Health (1K23HL140133).

Funding

This study was funded by the Leona M. and Harry B. Helmsley Charitable Trust

Declaration of interests

We declare no competing interests.

Ethics approval

Ethics approval was not required for this study since it used secondary data, which are available in the public domain. The Institutional Review Board of the Harvard Faculty of Medicine determined this work to be not human subject research requiring additional approval.

Data availability statement

Data from the Service Provision Assessment surveys are available in a public, open access repository through the DHS Program: http://dhsprogram.com/data/available-datasets.cfm.

References

1 Kyu HH, Abate D, Abate KH, *et al.* Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet* 2018;**392**:1859–922. doi:10.1016/S0140-6736(18)32335-3

2 Bukhman G, Mocumbi AO, Horton R. Reframing NCDs and injuries for the poorest billion: a Lancet Commission. *The Lancet* 2015;**386**:1221–2.

3 Ogoina D, Onyemelukwe GC. The role of infections in the emergence of non-communicable diseases (NCDs): Compelling needs for novel strategies in the developing world. *Journal of Infection and Public Health* 2009;**2**:14–29. doi:10.1016/j.jiph.2009.02.001

4 Moucheraud C. Service Readiness For Noncommunicable Diseases Was Low In Five Countries In 2013–15. *Health Affairs* 2018;**37**:1321–30. doi:10.1377/hlthaff.2018.0151

5 Jamison DT, Alwan A, Mock CN, *et al.* Universal health coverage and intersectoral action for health: key messages from Disease Control Priorities, 3rd edition. *The Lancet* 2018;**391**:1108–20. doi:10.1016/S0140-6736(17)32906-9

6 WHO Expert Committee on the Role of Hospitals at the First Referral Level & World Health Organization. Hospitals and Health for All: Report of a WHO Expert Committee on the Role of Hospitals at the First Referral Level. World Health Organization Technical Report Series 744. Geneva: : World Health Organization 1987. https://apps.who.int/iris/handle/10665/38113

7 Lerberghe W van, Lafort Y, World Health Organization. The Role of the Hospital in the District: Delivering or supporting primary health care? Geneva: : World Health Organization, Division of Strengthening of Health Services 1990. https://apps.who.int/iris/handle/10665/59744

8 Robles Aguilar G, Sumner A. Who Are the World's Poor? A New Profile of Global Multidimensional Poverty. Working Paper 499. Washington, DC: : Center for Global Development 2019. https://www.cgdev.org/publication/who-are-worlds-poor-new-profile-global-multidimensional-poverty (accessed 23 Jan 2019).

9 Gabrysch S, Campbell OM. Still too far to walk: Literature review of the determinants of delivery service use. *BMC Pregnancy and Childbirth* 2009;**9**:34. doi:10.1186/1471-2393-9-34

10 Sharma J, Leslie HH, Kundu F, *et al.* Poor Quality for Poor Women? Inequities in the Quality of Antenatal and Delivery Care in Kenya. *PLoS One* 2017;**12**. doi:10.1371/journal.pone.0171236

11 Service Provision Assessments (SPA). The DHS Program. https://dhsprogram.com/What-We-Do/Survey-Types/SPA.cfm (accessed 14 Feb 2018).

12 The DHS Program - Survey Search. The DHS Program. https://dhsprogram.com/What-We-Do/survey-search.cfm?pgtype=main&SrvyTp=type (accessed 14 Feb 2018).

13 United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2019 Revision. United Nations 2019. https://population.un.org/wpp/ (accessed 10 Apr 2020).

14 The World Bank. World Bank Country and Lending Groups. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (accessed 11 Jun 2020).

15 Kruk ME, Chukwuma A, Mbaruku G, *et al.* Variation in quality of primary-care services in Kenya, Malawi, Namibia, Rwanda, Senegal, Uganda and the United Republic of Tanzania. *Bull World Health Organ* 2017;**95**:408–18. doi:10.2471/BLT.16.175869

16 Gage AD, Leslie HH, Bitton A, *et al.* Assessing the quality of primary care in Haiti. *Bull World Health Organ* 2017;**95**:182–90. doi:10.2471/BLT.16.179846

17 Peck R, Mghamba J, Vanobberghen F, *et al.* Preparedness of Tanzanian health facilities for outpatient primary care of hypertension and diabetes: a cross-sectional survey. *Lancet Glob Health* 2014;**2**:e285–92. doi:10.1016/S2214-109X(14)70033-6

18 Mendis S, Al Bashir I, Dissanayake L, *et al.* Gaps in capacity in primary care in low-resource settings for implementation of essential noncommunicable disease interventions. *Int J Hypertens* 2012;**2012**:584041. doi:10.1155/2012/584041

19 van Mourik MSM, Cameron A, Ewen M, *et al.* Availability, price and affordability of cardiovascular medicines: a comparison across 36 countries using WHO/HAI data. *BMC Cardiovasc Disord* 2010;**10**:25. doi:10.1186/1471-2261-10-25

20 Olsen MH, Angell SY, Asma S, *et al.* A call to action and a lifecourse strategy to address the global burden of raised blood pressure on current and future generations: the Lancet Commission on hypertension. *Lancet* 2016;**388**:2665–712. doi:10.1016/S0140-6736(16)31134-5

21 Damasceno A, Mayosi BM, Sani M, *et al.* The causes, treatment, and outcome of acute heart failure in 1006 Africans from 9 countries. *Arch Intern Med* 2012;**172**:1386–94. doi:10.1001/archinternmed.2012.3310

22 Callender T, Woodward M, Roth G, *et al.* Heart failure care in low- and middle-income countries: a systematic review and meta-analysis. *PLoS Med* 2014;**11**:e1001699. doi:10.1371/journal.pmed.1001699

23 Carlson S, Duber HC, Achan J, *et al.* Capacity for diagnosis and treatment of heart failure in sub-Saharan Africa. *Heart* 2017;**103**:1874–9. doi:10.1136/heartjnl-2016-310913

24 Wyber R, Taubert K, Marko S, *et al.* Benzathine Penicillin G for the Management of RHD: Concerns About Quality and Access, and Opportunities for Intervention and Improvement. *Glob Heart* 2013;**8**:227–34. doi:10.1016/j.gheart.2013.08.011

25 Manne-Goehler J, Atun R, Stokes A, *et al.* Diabetes diagnosis and care in sub-Saharan Africa: pooled analysis of individual data from 12 countries. *Lancet Diabetes Endocrinol* 2016;**4**:903–12. doi:10.1016/S2213-8587(16)30181-4

26 Babar Z-U-D, Lessing C, Mace C, *et al.* The availability, pricing and affordability of three essential asthma medicines in 52 low- and middle-income countries. *Pharmacoeconomics* 2013;**31**:1063–82. doi:10.1007/s40273-013-0095-9

27 Meyer A-C, Dua T, Ma J, *et al.* Global disparities in the epilepsy treatment gap: a systematic review. *Bull World Health Organ* 2010;**88**:260–6. doi:10.2471/BLT.09.064147

28 Ba-Diop A, Marin B, Druet-Cabanac M, *et al.* Epidemiology, causes, and treatment of epilepsy in sub-Saharan Africa. *Lancet Neurol* 2014;**13**:1029–44. doi:10.1016/S1474-4422(14)70114-0

29 Spiegel DA, Droti B, Relan P, *et al.* Retrospective review of Surgical Availability and Readiness in 8 African countries. *BMJ Open* 2017;**7**. doi:10.1136/bmjopen-2016-014496

30 Alkire BC, Raykar NP, Shrime MG, *et al.* Global access to surgical care: a modelling study. *Lancet Glob Health* 2015;**3**:e316-323. doi:10.1016/S2214-109X(15)70115-4

31 Meara JG, Leather AJM, Hagander L, *et al.* Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *The Lancet* 2015;**386**:569–624.

32 Rhee JY, Garralda E, Torrado C, *et al.* Palliative care in Africa: a scoping review from 2005-16. *Lancet Oncol* 2017;**18**:e522–31. doi:10.1016/S1470-2045(17)30420-5

33 Knaul FM, Farmer PE, Krakauer EL, *et al.* Alleviating the access abyss in palliative care and pain relief-an imperative of universal health coverage: the Lancet Commission report. *Lancet* 2018;**391**:1391–454. doi:10.1016/S0140-6736(17)32513-8

34 Ministry of Health, Community Development, Gender, Elderly and Children, Government of the United Republic of Tanzania. Strategic plan and action plan for the prevention and control of non communciable diseases in Tanzania 2016-2020. 2016.https://extranet.who.int/ncdccs/Data/TZA_B3_NCD%20Stategic%20Plan%202016%20-%202020v0.3.pdf (accessed 14 Feb 2018).

35 Ministry of Health, Federal Democratic Republic of Ethiopia. National strategic action plan (NSAP) for prevention & control of non-communicable diseases in Ethiopia: 2014-2016. Addis Ababa, Ethiopia: : Ministry of Health, Federal Democratic Republic of Ethiopia https://www.iccp-portal.org/system/files/plans/ETH_B3_National%20Strategic%20Action%20Plan%20%28NSAP%29%20for%20Prevention%20and%20Control%20of%20Non-Communicable%20Diseases%20-%20Final.pdf (accessed 14 Feb 2018).

36 World Health Organization. Health workforce requirements for Universal Health Coverage and the Sustainable Development Goals. 2016.https://www.who.int/hrh/resources/health-observer17/en/ (accessed 14 Feb 2018).

37 Leslie HH, Sun Z, Kruk ME. Association between infrastructure and observed quality of care in 4 healthcare services: A cross-sectional study of 4,300 facilities in 8 countries. *PLOS Medicine* 2017;**14**:e1002464. doi:10.1371/journal.pmed.1002464

38 Kruk ME, Gage AD, Arsenault C, *et al.* High-quality health systems in the Sustainable Development Goals era: time for a revolution. *The Lancet Global Health* 2018;**6**:e1196–252. doi:10.1016/S2214-109X(18)30386-3

39 WHO Regional Office for Africa. PEN-Plus Meeting in Kigali – The management and treatment of non-communicable diseases at primary levels strengthened. https://www.afro.who.int/news/pen-plus-meeting-kigali-management-and-treatment-non-communicable-diseases-primary-levels (accessed 16 Sep 2019).

40 Joshi R, Alim M, Kengne AP, *et al.* Task shifting for non-communicable disease management in low and middle income countries--a systematic review. *PLoS ONE* 2014;**9**:e103754. doi:10.1371/journal.pone.0103754

41 Anand TN, Joseph LM, Geetha AV, *et al.* Task sharing with non-physician health-care workers for management of blood pressure in low-income and middle-income countries: a systematic review and meta-analysis. *The Lancet Global Health* 2019;**7**:e761–71. doi:10.1016/S2214-109X(19)30077-4

42 Eberly LA, Rusingiza E, Park PH, *et al.* 10-Year Heart Failure Outcomes From Nurse-Driven Clinics in Rural Sub-Saharan Africa. *Journal of the American College of Cardiology* 2019;**73**:977–80. doi:10.1016/j.jacc.2018.12.028

43 Atun R, Jaffar S, Nishtar S, *et al.* Improving responsiveness of health systems to non-communicable diseases. *The Lancet* 2013;**381**:690–7. doi:10.1016/S0140-6736(13)60063-X

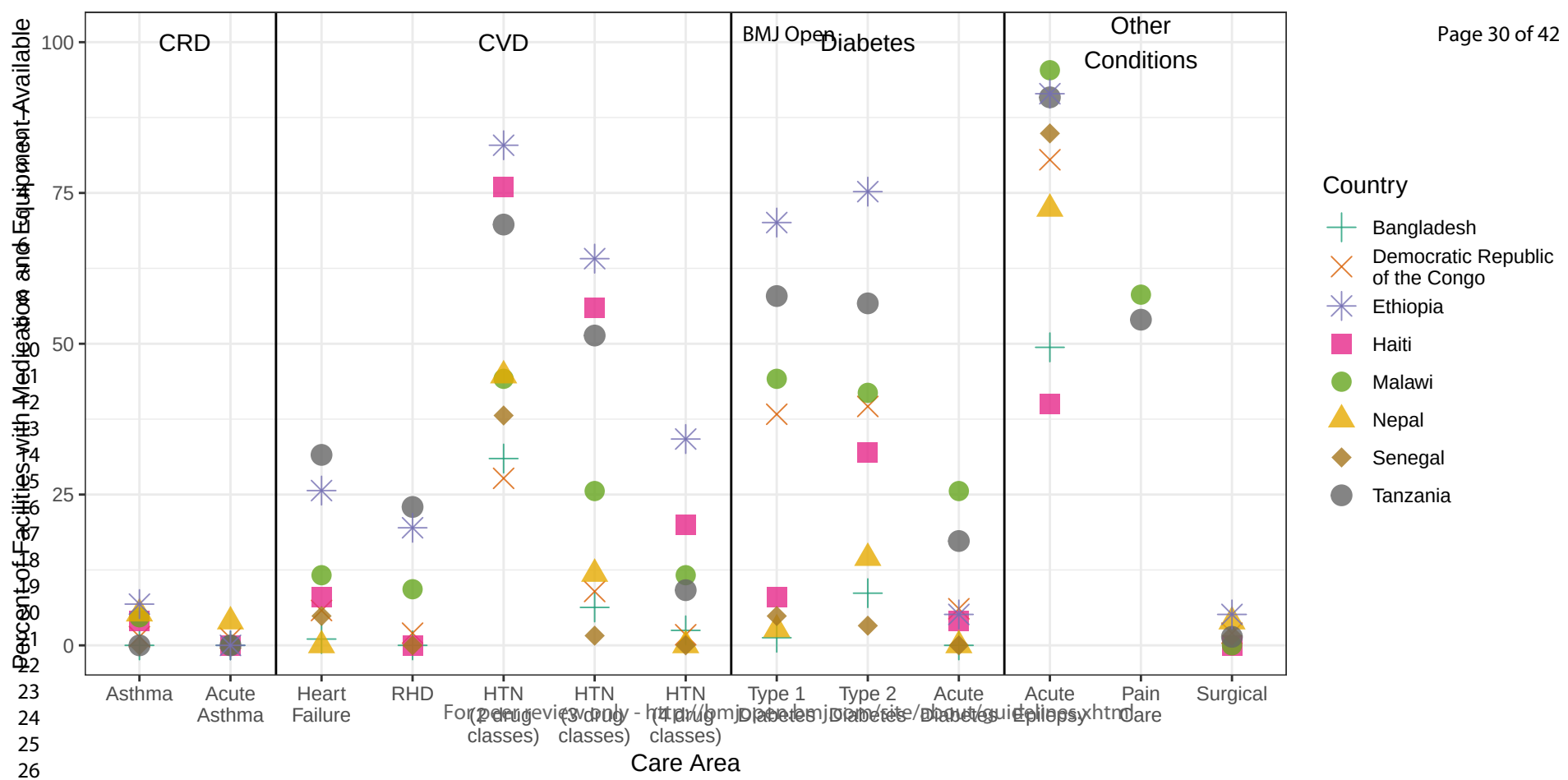
44 Gupta N, Bukhman G. Leveraging the lessons learned from HIV/AIDS for coordinated chronic care delivery in resource-poor settings. *Healthc (Amst)* 2015;**3**:215–20. doi:10.1016/j.hjdsi.2015.09.006

45 Nickerson JW, Adams O, Attaran A, *et al.* Monitoring the ability to deliver care in low- and middle-income countries: a systematic review of health facility assessment tools. *Health Policy Plan* 2015;**30**:675–86. doi:10.1093/heapol/czu043

46 Primary Health Care Performance Initiative (PHCPI). PHCPI. 2018.https://improvingphc.org/ (accessed 20 May 2019).

Figure 1. **Availability of complete essential equipment and medications for acute presentations and chronic care of NCDI conditions at public first-referral level hospitals in eight low-income countries**

CRD=Chronic respiratory disease, CVD=Cardiovascular disease, RHD=Rheumatic heart disease, HTN=Hypertension



Supplementary appendix

***Appendix Table 1*: Summary of Service Provision Assessments and facilities included in data analysis**

	Facilities Included in Analysis	Census or Sample of First-Referral Hospitals	Number of Surveyed Public Hospitals of Selected Level	Number of Surveyed Private Hospitals of Selected Level	Facilities not Surveyed of Selected Level	Number of Total Hospitals of Level of Interest in the Country, Private and Public (from SPA report)	Population[1]	Implied Catchment Size for Public and Private Facilities at Selected Level (facilities/population)	Catchment Size Described in Report
Bangladesh (2014)[2]	Public upazila health complexes	Sample	140	0	285	425 upazila health complexes, 53 district hospitals	159,405,279 (2014)	Upazila health complexes (375,000), district hospitals (3 million)	Not described
The Democratic Republic of the Congo (2017-18)[3]	Public non-tertiary, non-provincial hospitals	Sample (includes >90% of general referral hospitals)	283	200	491 of 524 general referral hospitals selected for sample*	524 referral hospitals (includes tertiary/provincial/national, report does not separate)	84,004,989 (2018)	All referral hospitals (160,000), non-tertiary/provincial referral hospitals (~165,000-175,000)	Not described
Ethiopia (2014)[4]	Public primary hospitals and general hospitals	Census	117	65	8	56 primary hospitals, 134 general hospitals	97,366,774 (2014)	Primary hospitals (1.7 million), General hospitals (727,000), Combined (512,000)	Targets: Primary hospital (60,000-100,000), General hospital (1-1.5 million)
Haiti (2013)[5]	Public community referral hospitals	Census	25	15	**	121 hospitals (includes other types, report does not separate), 40 community referral hospitals in dataset (census)	10,431,776 (2013)	Community referral hospitals (261,000)	Not described
Malawi (2013)[6]	Public district hospitals and rural/community hospitals	Census	43	22	**	119 hospitals (includes other types of hospitals, report does not separate); 65 district and rural/community hospitals in dataset (census)	16,577,147 (2013)	District and rural/community hospitals combined (255,000)	Not described
Nepal (2015)[7]	Public district hospitals	Census	76	0	0	76 district hospitals	28,656,282 (2015)	District hospitals (377,000)	Not described

	Facilities Included in Analysis	Census or Sample of First-Referral Hospitals	Number of Surveyed Public Hospitals of Selected Level	Number of Surveyed Private Hospitals of Selected Level	Facilities not Surveyed of Selected Level	Number of Total Hospitals of Level of Interest in the Country, Private and Public (from SPA report)	Population[1]	Implied Catchment Size for Public and Private Facilities at Selected Level (facilities/population)	Catchment Size Described in Report
Senegal (2016-17)[8]	Public hospitals	Continuous SPA, essentially a census with 2 combined years	37	33	***	68 hospitals	15,850,567 (2017)	Hospitals (233,000)	Public hospitals (423,000)
Tanzania (2014-15)[9]	Public district hospitals and district designated hospitals	Census	76	20	**	265 hospitals (includes other types of hospitals, report does not separate); 96 district and district designated hospitals in dataset (census)	53,879,957 (2015)	District hospitals and district designated hospitals (561,000)	Not described

*Calculation not possible with facility types in report table—some of the 524 hospitals include tertiary/provincial hospitals
**Calculation not possible with facility types in report table, but total number in dataset should be close to total since hospital sample was census
***Calculation not possible with Senegal survey combined from two years, but should be close to facility census combining the surveys

For 95% confidence intervals for estimates from countries without censuses of facilities, we used finite population corrections. In Bangladesh, we knew that there were 425 total facilities of interest, of which 140 were surveyed, so we corrected using 425 as the total population. In the DRC, tables in the SPA report gave total numbers of general referral hospitals but not the specific type of interest to us. The dataset allowed us to exclude tertiary/provincial hospitals, but we were not able to obtain the exact number of public first-referral hospitals. In the sample, there were 283 hospitals we included in the analysis. We know that 491 out of 524 hospitals (including private) were selected for the sample, so 33 were not included. Conservatively, no more than 316 (283+33) facilities could be in the population of hospitals of interest. We used this number for the finite population correction as a conservative cap (confidence intervals are therefore conservatively large.

***Appendix Table 2*: Variables excluded from Service Provision Assessment surveys or with >10% missing data, by country**

Country	Variables not included in survey	Variables with >10% missing data
Bangladesh	All surgical equipment, oral morphine	Oral penicillin, injectable morphine, injectable pethidine
The Democratic Republic of the Congo	Injectable morphine/pethidine, oral morphine	
Ethiopia	Oral penicillin, oral morphine	
Haiti	Oral penicillin, injectable morphine/pethidine, oral morphine	Some surgical equipment
Malawi	-	Oral penicillin
Nepal	Oral penicillin, benzathine penicillin, injectable morphine/pethidine, oral morphine	
Senegal	Oral penicillin, injectable morphine/pethidine, oral morphine	Analgesics
Tanzania	Oral penicillin	Oral morphine

*variables asked in only one country include: phenobarbitone tablets (Nepal), diazepam tablets (Bangladesh), carbamazepine tablets (Nepal)

Appendix Table 3: **Indicators in modified Multi-dimensional Poverty Index**

Dimension	Indicator	Deprivation cut-off
Education	Schooling	No household member has completed five years of schooling
	Attendance	Any school-aged child in the household is not attending school up to class 8
Standard of living	Electricity	The household has no electricity
	Sanitation	The household's sanitation facility is not improved or it is shared with other households
	Water	The household does not have access to safe drinking water or safe water is more than a 30-minute walk, round trip
	Floor	The household has a dirt, sand, or dung floor
	Cooking fuel	The household cooks with dung, wood, or charcoal
	Assets	The household does not own more than one of the following: radio, TV, telephone, bike, motorbike, or refrigerator; however, if the household owns a car or truck, they do not count as deprived in this category

***Appendix Table 4*: Source of data for Multi-dimensional Poverty Index, by country**

Country	**Poverty Index Survey**
Bangladesh	DHS 2014
The Democratic Republic of the Congo	DHS 2013-14
Ethiopia	DHS 2011*
Haiti	DHS 2012*
Malawi	DHS 2015-16
Nepal	MICS 2014
Senegal	DHS 2015*
Tanzania	DHS 2015-16

*More recent DHS 2016 available. Estimates do not reflect these new datasets.
Differences in year between poverty and SPA surveys in each country are 3 years or fewer (DRC 3-4 years)

Subnational poverty, hospital density, and availability of services.

Poverty and service availability

We defined the prevalence of extreme poverty using a modified version of the Multidimensional Poverty Index.[10] We defined extreme poverty using 5 of 8 deprivations (Appendix Table 3). Using household survey data from recent surveys (Appendix Table 4), we found the proportion of the population in districts or regions that met this definition of extreme poverty.

To assess whether there might be an association between poverty prevalence in the subnational areas in which hospitals are located and the availability of medications and equipment at these hospitals, we conducted country-specific regressions using two different specification strategies.

In our construction of the sets of medication and equipment, there was information loss because the absence of one item made the whole set unavailable. To include this information in our assessment of the possible association between poverty and availability of medications and equipment, we included each of the individual items that are part of the various disease-specific sets (main text Table 1), deduplicating the items contained in multiple sets. We calculated the percent of the total items available at each facility. This proportion, transformed to logit space, was the outcome in both of our regression specifications.

In the first regression specification, we regressed the logit-transformed proportion of total items available in hospitals (h) on the proportion of population living in poverty ($\%\,Pop\ Poverty$) in the subnational area (region or district) where the hospital is located. We conducted a separate regression for each country because we anticipated different associations were possible in different countries based on differences in health systems across countries.

$$Logit(\%\ Items\ Available)_{c,h} = \beta_{1,c} + \beta_{2,c} * \%\ Pop\ Poverty_{c,h} + \varepsilon_{c,h}$$

The second specification allowed for nonlinear associations between the two variables. We created bins of facilities, grouped using cutoffs in the poverty prevalence variable. To illustrate, in a country where hospitals were binned into four groups based on poverty prevalence, the groups would be included as "dummy" variables (I) as follows, where I_2, I_3, and I_4 represent the second two groups, while the first group is the reference group.

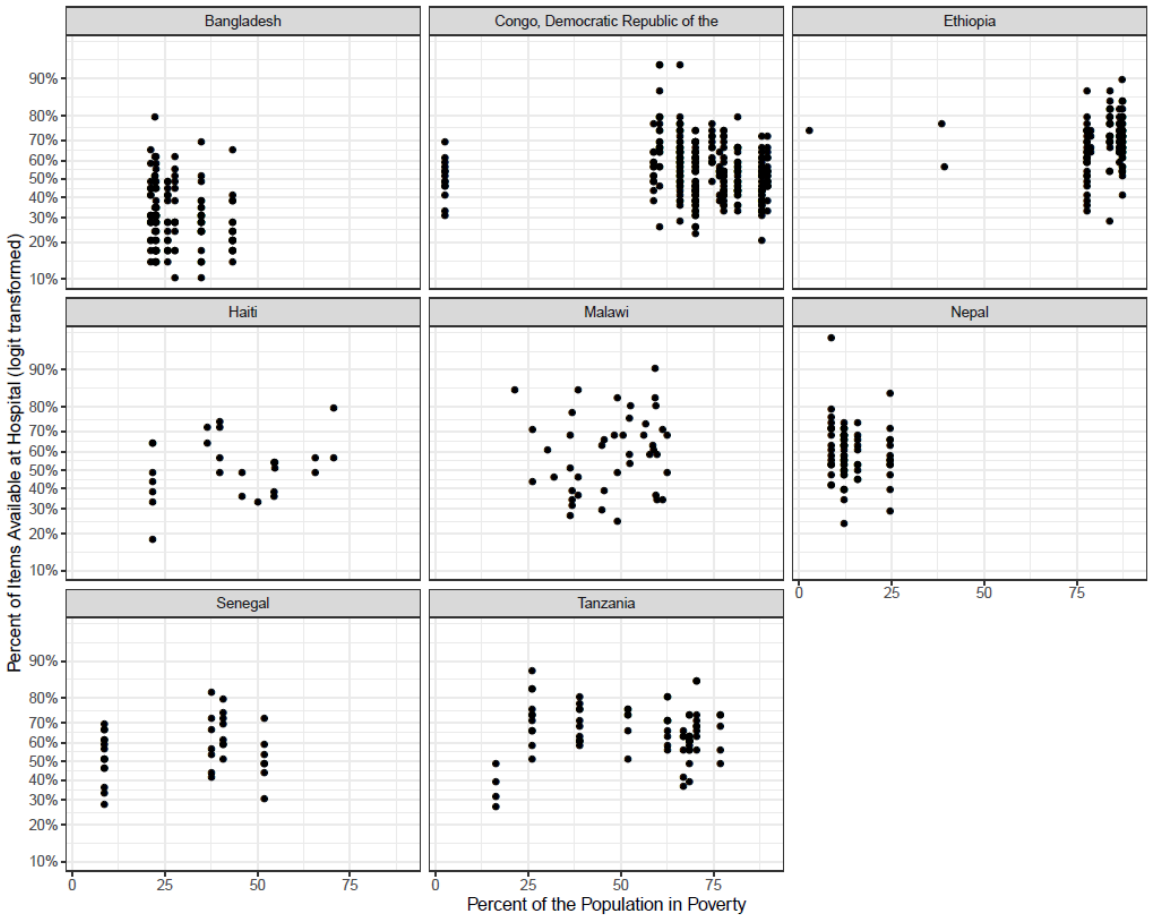
$$Logit(\%\ Items\ Available)_{c,h} = \beta_{1,c} + \beta_{2,c} * I_{2,c,h} + \beta_{3,c} * I_{3,c,h} + \beta_{4,c} * I_{4,c,h} + \varepsilon_{c,h}$$

We did two sets of regressions using groups created in two different ways—based on the quartiles of poverty prevalence and based on dividing the poverty prevalence range of the subnational units in the country into four categories evenly spaced on the scale of poverty prevalence. To create the first category, we ranked the hospitals by poverty prevalence in the corresponding subnational unit and calculated the cumulative proportion of hospitals. We split groups based on the cumulative proportions closest to 25%, 50%, and 75%. To create the second category, we subtracted the poverty prevalence in the lowest-poverty area from the poverty prevalence in the highest-poverty area. We then divided this range into four even parts and assigned hospitals to the four groups using the poverty prevalence in the subnational unit corresponding to the hospital. Sometimes, one of the parts of the range did not contain any of the public first-referral level hospitals. For instance, in Ethiopia, the ranges were approximately 2.8-23.925%, 23.925-45.05%, 45.05-66.175%, and 66.175-87.3%, but there were no subnational units with between 45.05% and 66.175% poverty prevalence. In cases with no subnational units in a particular quartile, the model simply had fewer categories. Ranges in the other countries were as follows: Bangladesh (22.1-26.725%, 26.725-32.25%, 32.25-37.775%, and 37.775-43.3%), DRC (2.6-24.35%, 24.35-46.1%, 46.1-67.85%, and 67.85-89.6%), Haiti (21.7-33.925%, 33.925-46.15%, 46.15-58.375%, and 58.375-70.6%), Malawi (21.4-31.675%, 31.675-41.95%, 41.95-52.225%, and 52.225-62.5%), Nepal (8.7-12.69167%, 12.69167-16.65%, 16.65-20.60833%, and 20.60833-24.56667%), Senegal (8.7-19.5%, 19.5-30.3%, 30.3-41.1%, and 41.1-51.9%), and Tanzania (16.3-31.45%, 31.45-46.6%, 46.6-61.75%, and 61.75-76.9%).

Scatter plots of the percent of items available and the percent of the population in poverty are found in Appendix Figure 1. Points on a vertical line indicate facilities located within the same subnational unit. While

some subnational units do visually appear to have different average availability than others, there is relatively little visual evidence of systematic trends in availability with respect to poverty. Results from the first regression specification are in Appendix Table 5. There was a significant association in the Democratic Republic of the Congo ($p < 0.05$) and an association that would meet looser criteria for significance in Bangladesh ($p < 0.1$). The degree of the associations were not too large—they implied differences of 8 percentage points between the lowest-poverty (2.6%) and highest-poverty (89.6%) units in the Democratic Republic of the Congo and 6 percentage points between the lowest-poverty (21.2%) and highest-poverty (43.3%) units in Bangladesh, for instance, corresponding to roughly two to four of the 41 items included in creating the proportions. The regression coefficients on the poverty term were insignificant in the other countries and their point estimates were positive, rather than negative, in all but Nepal.

***Appendix Figure 1*: Percent of medication and equipment items available in hospitals and percent of the population living in poverty in the region or district of the hospitals, by country**



***Appendix Table 5*: Regression results for association between availability of medications and equipment at public first-referral level hospitals and poverty in corresponding subnational unit, specification 1**

Country	Intercept β (SE)	Logit Poverty Proportion β (SE)
Bangladesh	-0.46103 (0.21740)†	-0.01428 (0.00743)*
Democratic Republic of the Congo	0.44823 (0.14464) ‡	-0.00393 (0.00196)†
Ethiopia	0.43452 (0.41700)	0.00457 (0.00502)
Haiti	-0.30321 (0.36910)	0.00866 (0.00806)
Malawi	-0.05541 (0.55816)	0.00914 (0.01145)
Nepal	0.57292 (0.19222) ‡	-0.01375 (0.01287)
Senegal	0.10679 (0.18376)	0.00560 (0.00538)
Tanzania	0.61029 (0.20044)‡	0.00048 (0.00351)

*p < 0.1, †p < 0.05, ‡p < 0.01

The second set of results, using regressions with hospitals grouped based on ranges of poverty prevalence, gave results that were similar in some ways but differed in others. The quartile regression found lower availability in the highest-poverty quartile in Bangladesh ($p < 0.05$), while the regression based on the ranges found that the hospitals in the highest poverty range showed lower availability under weaker criteria for significance ($p < 0.1$). In the Democratic Republic of the Congo, the selection of bins made a large difference in interpretation. Using quintiles showed lower availability in hospitals in the poverty quintiles above the first, while using ranges found higher availability in the third range compared to the first. The plot showed a downward trend in availability with poverty in the units with poverty over 50%, but the subnational unit with very low poverty created an odd distribution. Similarly, in Ethiopia, the range was made large by few hospitals in low-poverty areas, but the specification using quartiles found higher availability in higher-poverty quartiles ($p < 0.01$). In Haiti, both methods, but particularly the quartile method, suggested higher availability in hospitals in higher-poverty areas. Both methods showed higher availability in the third group in Senegal. No association was found in Malawi, Nepal, or Tanzania.

While both the continuous and binned specifications suggested lower availability in higher-poverty subnational units in Bangladesh and the Democratic Republic of the Congo, the story appears more complex. The trend in Congo appears to be mostly among the subnational units in higher-poverty areas rather than compared to the hospitals in the low-poverty area, evidenced by Appendix Figure 1 and the differing results from the bins using the range method rather than the quartile method. Additionally, the binned methods suggested availability was higher in high-poverty areas in Haiti and Ethiopia, though somewhat inconsistently between the two binning methods.

From this analysis, we can conclude that there is some evidence for differences in availability of medications and equipment across public first-referral level hospitals that may correlate with poverty, though not in a consistent manner across countries or across methods of evaluation. There appear to be both positive and negative correlations in different locations. More detailed data, for example, relating to poverty in specific facility catchment areas, would be necessary to make nuanced claims about inequities in availability of medications and equipment. There is variation in availability within subnational units (points oriented vertically in Appendix Figure 1), which means that facility catchment area factors, for example, could correlate with availability. Further, to understand the drivers of any patterns, more complex administrative data, for instance on supply chains and procurement, would be necessary.

Poverty and hospital density per population

Another factor contributing to inequitable access to care for individuals and families living in poverty is geographic access to health facilities. The density of health facilities tends to be higher in urban areas for many reasons, including availability of human resources and proximity to larger populations. We tested whether the density of hospitals per population in subnational areas was associated with the prevalence of extreme poverty, both for public first-referral level hospitals and hospitals overall. We excluded Bangladesh and the Democratic Republic of the Congo from this analysis. The survey in Bangladesh did not contain a

census of first-referral level hospitals, and the survey in the Democratic Republic of the Congo was not as close to a complete census as the surveys in the other countries. We totaled the number of first-referral level and overall hospitals per subnational area, and calculated the density of hospitals per population. We hypothesized that the density of public first-referral level hospitals per population in a subnational area would not be associated with subnational poverty because governments tend to distribute these hospitals to have relatively consistent catchment areas and to cover the whole population. We hypothesized that the density of hospitals overall in a subnational area would be lower in subnational areas with higher poverty because hospitals tend to be more concentrated in large urban areas, which tend to have lower poverty prevalence than rural areas. We regressed the hospital density per capita in each subnational area (s) on the proportion of the population in extreme poverty, pooling countries (c) and including a set of country indicators (I) to account for country differences in overall density of facilities.

$$Hospitals\ per\ population_{c,s} = \beta_1 + \beta_2 * \%\ Pop\ Poverty_{c,s} + \beta_{3-7} * I_c + \varepsilon_c$$

We also tested a specification including the log of the subnational population in the subnational area as a predictor, as one might expect high-population areas to have a greater density of hospitals because of concentration of resources in large urban centers.

We found no association between the density of public first-referral level hospitals per population and poverty prevalence. Meanwhile, the density of hospitals per population overall was lower in higher-poverty areas ($p < 0.01$). The log of the population was a significant predictor, but its inclusion did not substantially change the results. These findings are consistent with our hypothesis that the density of public first-referral level hospitals is relatively consistent with respect to poverty prevalence but that hospitals overall are more common in higher-population, lower-poverty areas. These findings reinforce that availability of services at public first-referral level hospitals is important for equity, as these facilities are more evenly distributed with respect to poverty prevalence. However, these findings do not incorporate information about other aspects of accessibility including travel time, distance, or fees, for example.

***Appendix Table 6*: Regression results for association between availability of medications and equipment at public first-referral level hospitals and poverty in corresponding subnational unit, specification 2**

Country	Hospitals Grouped in Quartiles		Hospitals Grouped in Even % Ranges	
Bangladesh				
	Intercept β (SE)	-0.62287 (0.11719)‡	Intercept β (SE)	-0.80940 (0.07400) ‡
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	-0.30865 (0.16214)*	R2 β (SE)	0.07353 (0.19378)
	Q3 β (SE)	-0.20948 (0.16996)	R3 β (SE)	-0.12964 (0.15309)
	Q4 β (SE)	-0.38529 (0.15402)†	R4 β (SE)	-0.28969 (0.17061)*
Democratic Republic of the Congo				
	Intercept β (SE)	0.43720 (0.06017)‡	Intercept β (SE)	-0.00119 (0.15268)
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	-0.41962 (0.10040)‡	R2 β (SE)	ND
	Q3 β (SE)	-0.26806 (0.08826)‡	R3 β (SE)	0.51809 (0.16598) ‡
	Q4 β (SE)	-0.54222 (0.09452)‡	R4 β (SE)	0.04153 (0.15815)
Ethiopia				
	Intercept β (SE)	0.51980 (0.09484)‡	Intercept β (SE)	1.06471 (0.55630)*
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	0.47039 (0.13900)‡	R2 β (SE)	-0.33381 (0.68133)
	Q3 β (SE)	0.40906 (0.15384)‡	R3 β (SE)	ND
	Q4 β (SE)	0.33925 (0.12635)‡	R4 β (SE)	-0.25477 (0.55874)
Haiti				
	Intercept β (SE)	-0.26178 (0.20445)	Intercept β (SE)	-0.26178 (0.22762)
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	0.88173 (0.30094)‡	R2 β (SE)	0.64785 (0.31168)*
	Q3 β (SE)	-0.10821 (0.30094)	R3 β (SE)	0.03122 (0.33505)
	Q4 β (SE)	0.59917 (0.30094)*	R4 β (SE)	0.71651 (0.37747)*
Malawi				
	Intercept β (SE)	0.31416 (0.29877)	Intercept β (SE)	0.71179 (0.41719)*
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	-0.21344 (0.36996)	R2 β (SE)	-0.69985 (0.48718)
	Q3 β (SE)	0.40502 (0.41061)	R3 β (SE)	-0.51035 (0.5014)
	Q4 β (SE)	0.20861 (0.39266)	R4 β (SE)	-0.10884 (0.45901)
Nepal				
	Intercept β (SE)	0.60827 (0.13866)‡	Intercept β (SE)	0.41107 (0.08195) ‡
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	-0.30927 (0.1935)	R2 β (SE)	-0.08995 (0.20569)
	Q3 β (SE)	-0.28595 (0.20214)	R3 β (SE)	ND
	Q4 β (SE)	-0.29735 (0.18514)	R4 β (SE)	-0.10801 (0.18465)
Senegal				
	Intercept β (SE)	0.09308 (0.13972)	Intercept β (SE)	0.09308 (0.13939)
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	0.32670 (0.24770)	R2 β (SE)	ND
	Q3 β (SE)	0.58337 (0.23691)†	R3 β (SE)	0.46359 (0.19713)†
	Q4 β (SE)	-0.05308 (0.2477)	R4 β (SE)	-0.05308 (0.24711)
Tanzania				
	Intercept β (SE)	0.57313 (0.14036) ‡	Intercept β (SE)	0.57313 (0.14786) ‡
	Q1 β (SE)	Ref	R1 β (SE)	Ref
	Q2 β (SE)	0.23783 (0.17626)	R2 β (SE)	0.22976 (0.22732)
	Q3 β (SE)	-0.22383 (0.18377)	R3 β (SE)	0.25603 (0.27662)
	Q4 β (SE)	0.23898 (0.20201)	R4 β (SE)	0.01739 (0.17122)

*p < 0.1, †p < 0.05, ‡p < 0.01, ND=No Data

Appendix References

1 United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2017 Revision. United Nations 2017. https://population.un.org/wpp/

2 National Institute of Population Research and Training, Associates for Community and Population Research, ICF International. Bangladesh health facility survey 2014 final report. Dhaka, Bangladesh: : NIPORT, ACPR, and ICF International 2016. https://dhsprogram.com/pubs/pdf/SPA23/SPA23.pdf (accessed 14 Feb 2018).

3 Ecole de Santé Publique de Kinshasa, ICF. République Démocratique du Congo Évaluation des Prestations des Services de soins de Santé (EPSS) 2017-2018. Kinshasa, Democratic Republic of the Congo: : ESPK and ICF 2019. https://dhsprogram.com/pubs/pdf/SPA30/SPA30.pdf (accessed 1 Jul 2019).

4 Ethiopian Public Health Institute, Federal Ministry of Health, ICF International. Ethiopia service provision assessment plus (ESPA+) survey 2014. Addis Ababa, Ethiopia: : EPHI, FMOH, and ICF International 2014. https://www.ephi.gov.et/images/pictures/FINAL%20draft%20SPA+%20%20REPORT%20survey%20tools%20adjusted%20-%20Dec%2024%20%202015.pdf (accessed 14 Feb 2018).

5 Institut Haïtien de l'Enfance, ICF International. Haiti Évaluation de la Prestation des Services de Soins de Santé 2013. Rockville, Maryland, USA: : IHE and ICF International 2014. https://dhsprogram.com/pubs/pdf/SPA19/SPA19.pdf (accessed 14 Feb 2018).

6 Ministry of Health, ICF International. Malawi service provision assessment 2013-14. Lilongwe, Malawi: : MoH and ICF International 2014. https://dhsprogram.com/pubs/pdf/SPA20/SPA20[Oct-7-2015].pdf (accessed 14 Feb 2018).

7 Ministry of Health, New ERA, Nepal Health Sector Support Program, *et al*. Nepal health facility survey 2015 final report. Kathmandu, Nepal: : Ministry of Health, Nepal 2017. https://dhsprogram.com/pubs/pdf/SPA24/SPA24.pdf (accessed 14 Feb 2018).

8 Agence Nationale de la Statistique et de la Démographie, ICF. Sénégal : Enquête Continue sur la Prestation des Services de Soins de Santé (ECPSS) 2017. Dakar, Sénégal: : ANSD and ICF 2018. https://dhsprogram.com/pubs/pdf/SPA27/SPA27.pdf (accessed 1 Jul 2019).

9 Ministry of Health and Social Welfare [Tanzania Mainland], Ministry of Health [Zanzibar], National Bureau of Statistics, *et al*. Tanzania Service Provision Assessment Survey (TSPA) 2014-15. Dar es Salaam, Tanzania: : MoHSW, MoH, NBS, OCGS, and ICF International https://dhsprogram.com/pubs/pdf/SPA22/SPA22.pdf (accessed 14 Feb 2018).

10 Robles Aguilar G, Sumner A. Who Are the World's Poor? A New Profile of Global Multidimensional Poverty. Working Paper 499. Washington, DC: : Center for Global Development 2019. https://www.cgdev.org/publication/who-are-worlds-poor-new-profile-global-multidimensional-poverty (accessed 23 Jan 2019).

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract ***"Cross-sectional" in title (page 1, line 1)***
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found ***Summary provided in abstract (lines 61-69)***
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported ***Included in introduction (lines 105-124)***
Objectives	3	State specific objectives, including any prespecified hypotheses ***Objectives stated at end of introduction (line 125-132)***
Methods		
Study design	4	Present key elements of study design early in the paper ***Included in methods (starting line 137)***
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection ***Setting, locations, dates of surveys, and information on the availability of surveys included in methods (lines 145-152)***
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants ***Description of surveys included in analysis is in second paragraph of methods (line 145)***
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable ***Availability defined, sets of medications and equipment defined, extreme poverty operationalized in data analysis section of methods (starting line 189 and Table 1, line 219)***
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group ***Descriptions of surveys included, availability defined in methods (line 189 and Table 1, line 219)***
Bias	9	Describe any efforts to address potential sources of bias ***Strategies to handle limitations of data included in data analysis section of methods (starting line 196)***
Study size	10	Explain how the study size was arrived at ***Data from previously collected publicly available surveys, N/A***
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why ***Included in definitions and descriptions of sets of medications and equipment in methods, variables were binary (Table 1, line 219)***
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding ***Statistical methods described in data analysis section of methods (line 214, 230)***
		(*b*) Describe any methods used to examine subgroups and interactions ***Analysis by country for particular set of facilities. Facilities defined starting line***

		168.
		(*c*) Explain how missing data were addressed ***Missingness described in data analysis section of methods (starting line 198)***
		(*d*) If applicable, describe analytical methods taking account of sampling strategy ***Described in methods and referenced to original survey sources (starting line 153)***
		(*e*) Describe any sensitivity analyses ***Sensitivity analysis of possible association between availability of medications and equipment and poverty described in methods with reference to appendix for further detail (line 240)***
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed ***Reported number of facilities in first paragraph of results (line 250), full detail in Appendix Table 1***
		(b) Give reasons for non-participation at each stage ***Explanation of sampling given in methods section (line 153)***
		(c) Consider use of a flow diagram ***We did not consider a flow diagram to be necessary***
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders ***There are not individual participants. Table 1 describes equipment and medications. Appendix Table 1 describes details on country surveys.***
		(b) Indicate number of participants with missing data for each variable of interest ***Missingness of particular variables described in methods section (starting line 198) and in Appendix Table 2. Variables with high missingness noted in Tables 2-4 and excluded from reporting.***
Outcome data	15*	Report numbers of outcome events or summary measures ***Proportions of facilities with availability of different medications and equipment reported in tables, along with the number of facilities surveyed, see tables***
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included ***Estimates given with 95% confidence interval for samples, no confidence intervals included for country surveys that were intended to include a census of public first-referral hospitals.***
		(*b*) Report category boundaries when continuous variables were categorized ***Continuous variables reported as continuous in main text. Sensitivity analysis in appendix reports categories of extreme poverty prevalence.***
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period ***Not applicable***
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses ***Results from multiple regression specifications described briefly at end of results section and presented in full detail in appendix (line 368)***
Discussion		
Key results	18	Summarise key results with reference to study objectives

		First paragraph of discussion section summarizes results with reference to objectives (line 378)
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias ***Limitations paragraph in discussion section lists and contextualizes limitations. (line 443)***
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence ***Study is interpreted with reference to evidence form other studies in discussion and interpretation is summarized at the end of the discussion section.***
Generalisability	21	Discuss the generalisability (external validity) of the study results ***We discuss generalizability across countries as well as across disease types (line 436, for instance)***
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based ***Funding and role of funders is reported (line 519)***

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.